COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

February 1955

Montville Station of Connecticut Light & Power Co.

New Steam Generator at Weirton Steel Company

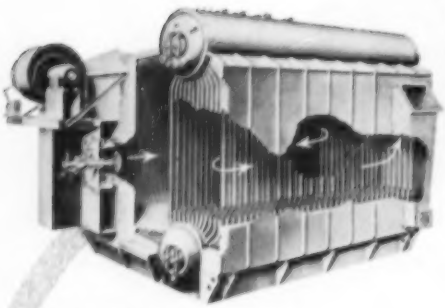
Control of Engineering Costs

Economic Size of Generating Units

STANDARD BOILERS THAT SET INDUSTRY STANDARDS

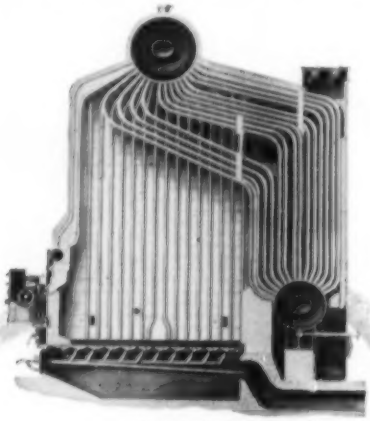
Whatever your steam needs, in the complete C-E line of fuel burning and steam generating equipment, you will find a type and size just right for you.

In the moderate capacity range, for example—from 4,000 to 120,000 pounds of steam per hour—the three *standardized* C-E Boilers shown here offer advantages of economy and performance that make them standout values in a wide range of applications.



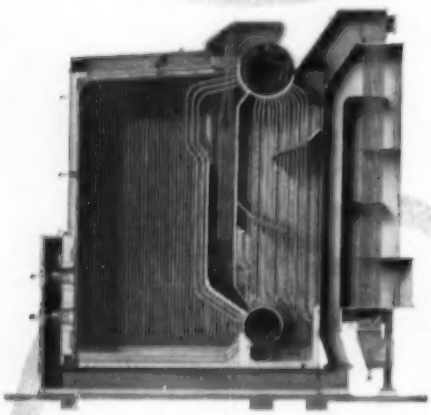
C-E Package Boiler, Type VP

4,000 to 40,000 lb steam per hr . . . pressures to 500 psi . . . for pressure firing of oil or gas . . . completely shop-assembled, needs only simple concrete slab for foundation. Has more water-cooled area per unit of furnace volume than any other boiler of its size and type. Large lower drum permits simple, symmetrical tube arrangement . . . great water storage capacity . . . easy access. Low-speed centrifugal fan is unusually quiet in operation. Simple baffle arrangement means low draft loss . . . simple soot blowing . . . no dead pockets . . . high heat absorption.



C-E Vertical-Unit Boiler, Type VU-10

10,000 to 60,000 lb steam per hr . . . pressures to 475 psi . . . superheat to 200 F in larger sizes . . . for coal, oil or gas . . . bottom-supported, needs no outside supporting steel. Boiler is efficient over a wide range of output, and is easy to operate and maintain. All parts are readily accessible for inspection. Regardless of fuel, the same general cross-sectional arrangement of drums, convection bank and furnace cooling is used. Uniform design through each transverse section assures even water level in drum, and uniform expansion.



C-E Vertical-Unit Boiler, Type VU-55

50,000 to 120,000 lb steam per hr . . . pressures of 250 or 500 psi . . . superheat and heat recovery equipment if desired . . . for oil or gas . . . bottom-supported, needs no outside supporting steel. This boiler is of symmetrical design. Thus gas temperature is constant across the full boiler width. The narrow, high furnace . . . integral design of boiler and preheater . . . absence of exterior ductwork . . . compactness—all help the VU-55 achieve standards of performance closely approaching that of large central station boilers.

Other C-E Industrial Boilers

In addition to the standard boilers shown here, Combustion offers many other 2-drum designs, for capacities to 350,000 pounds of steam per hour, for any commercially available fuel, for pressures to 1375 psi, and temperatures to 960 F. Heat recovery equipment is available. So — whatever your steam needs — call Combustion for details on the complete line of C-E Industrial Boilers.

B-767A

COMBUSTION ENGINEERING

C-E

Combustion Engineering Building
200 Madison Avenue, New York 16, N. Y.

BOILERS, FUEL BURNING & RELATED EQUIPMENT; PULVERIZERS, AIR SEPARATORS & FLASH DRYING SYSTEMS; PRESSURE VESSELS; AUTOMATIC WATER HEATERS; SOIL PIPE

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

Vol. 26 **No. 8**

February 1955

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BPA

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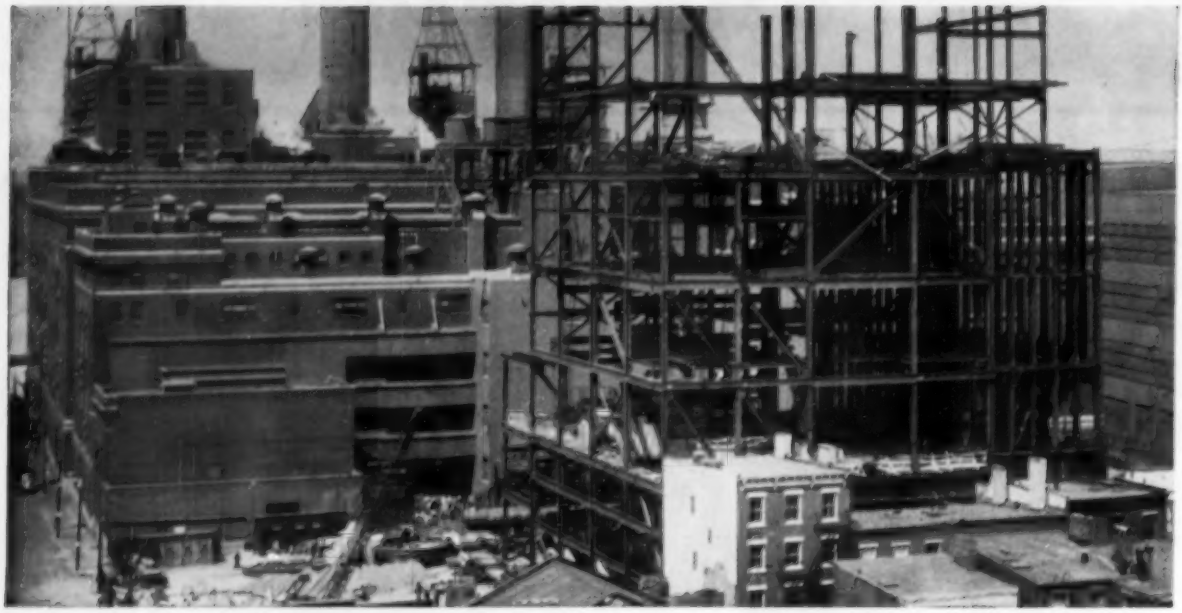


CHEMICAL CLEANING REMOVED MILL SCALE FROM BOILER AFTER ERECTION

Dowell Service gave quick, effective cleaning assuring more efficient operation

To provide more extensive service for its customers, a large power company installed a new 1,370,000 lb. per hour boiler. Specifications on this equipment called for Dowell Chemical Cleaning Service to remove any oil, grease, protective coatings, mill scale and rust from the boiler after erection.

To accomplish the purpose, Dowell engineers filled the boiler with solvents especially designed for the job. Using Dowell's equipment, manpower and pump trucks, the entire cleaning job was performed in a few hours.

Dowell has removed as much as three thousand pounds of mill scale and iron oxide from a new boiler.

Unless it is removed, mill scale may retard heat transfer, slough off abrading particles, and act as a base for corrosion. And considerable annoyance may result from black boiler water. The removal of mill scale after equipment is erected can also eliminate much of the extra care required in the handling of previously sand blasted or pickled tubes.

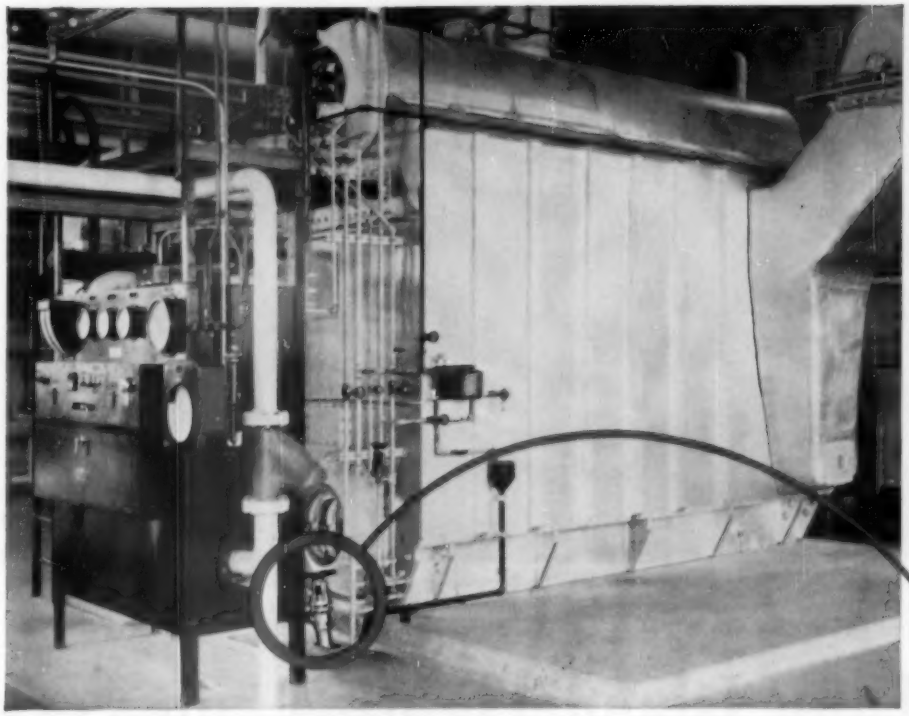
Maintenance engineers in industrial plants throughout the country have learned to rely on Dowell Service for fast, effective and economical cleaning of their operating equipment. How about you?

Experienced Dowell engineers are available to make estimates on your particular problems. Call Dowell today, or write to DOWELL INCORPORATED, Tulsa 1, Okla., Dept. B-25.

cleaning service for industry

DOWELL

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY



COMBUSTION ENGINEERING ADOPTS YARWAY SEATLESS BLOW-OFF VALVES FOR PACKAGE BOILERS

Combustion Engineering, Inc. on this package boiler installation at the Orangeburg Pipe Plant in California, again includes Yarway Seatless Blow-Off Valves as part of the "package."

It's a popular idea—and growing fast. All *good* package-type boiler installations are *better* when equipped with Yarway Seatless Blow-Off Valves.

More and more boilermakers are standardizing on Yarways, and more and more boiler users are expecting the advantages of Yarway Blow-Off Valves on their package units.

Get the full story on why more than 15,000 boiler plants use Yarway Blow-Off Valves, some for 30 to 40 years.

YARNALL-WARING COMPANY

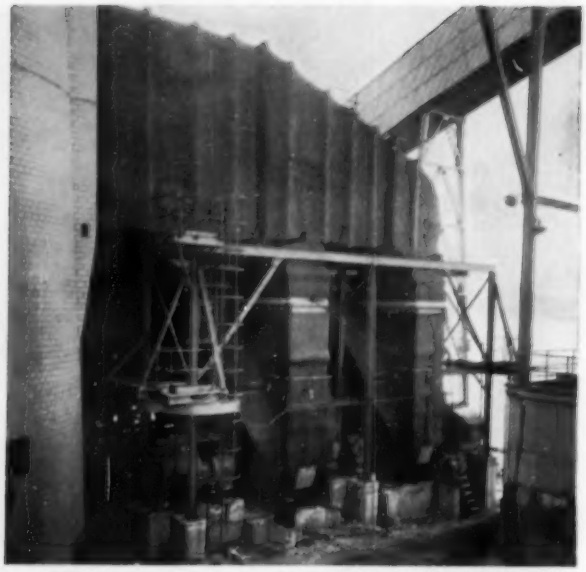
100 Mermaid Avenue, Philadelphia 18, Pa.

BRANCH OFFICES IN PRINCIPAL CITIES

Yarway Type "B" Seatless Tandem Blow-Off Valve. Note balanced sliding plunger design with no seat to score, wear, clog or leak. Pressures to 400 psi.

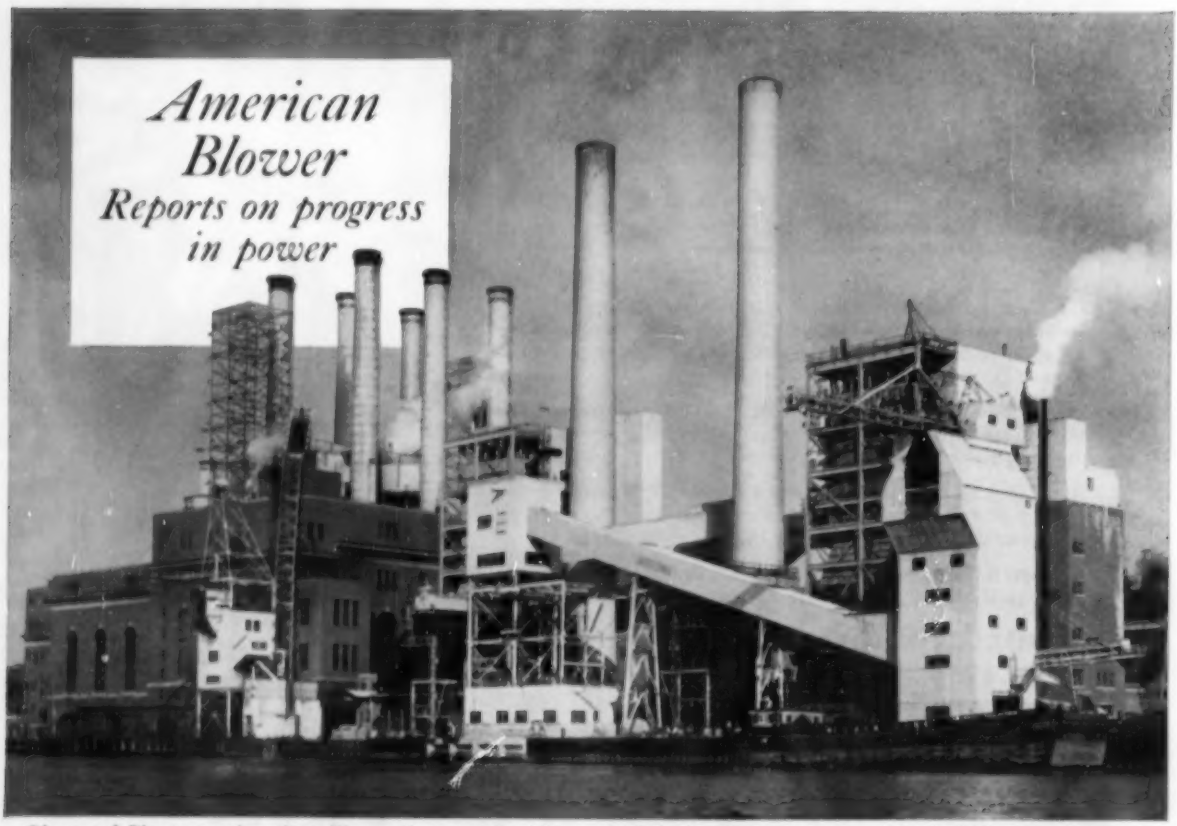
YARWAY **BLOW-OFF VALVES**

1. Two new units at Long Island Lighting's Glenwood Plant add 220 Mw to plant's capacity. Note outdoor turbines (foreground) — first in northeast area of U.S.

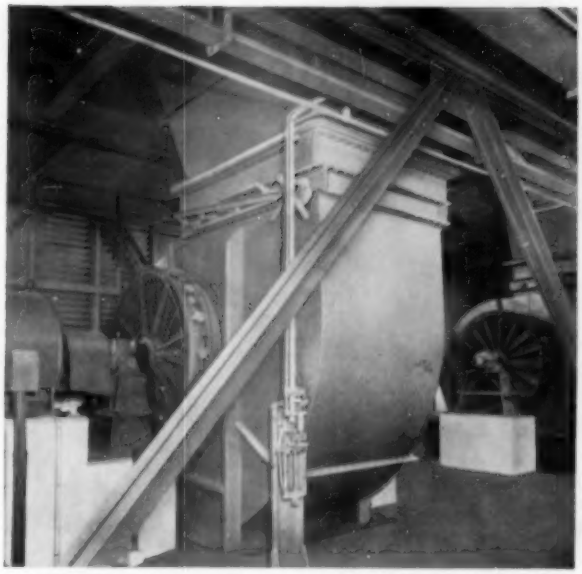


2. These two American Blower Induced Draft Fans are installed on unit #5 at Glenwood Plant. Each has capacity of 197,000 cfm @ 275°F @ 17.10 sp. @ 703 rpm.

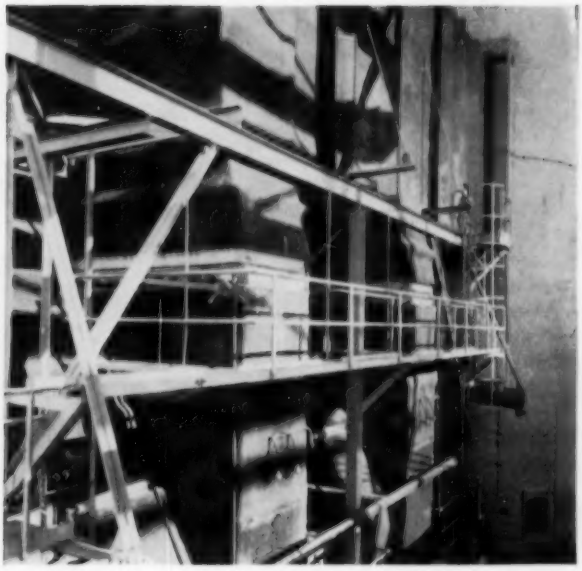
Long Island Lighting pioneers



Glenwood Plant uses American Blower Fans on six older units and new outdoor-type units (right). Long Island Lighting's other generating plants include: Port Jefferson, Far Rockaway and Edward F. Barrett stations.



3. American Blower Forced Draft Fans on Glenwood's #4 unit are each rated @ 135,000 cfm @ 100°F @ 12.75 sp. @ 875 rpm.



4. These American Blower Induced Draft Fans are installed on Glenwood's #4 unit. Each fan is rated at 197,000 cfm @ 275°F @ 17.10 sp. @ 703 rpm.

use of outdoor-type units in Northeast; operations reflect design progress!

Leading power company shows *progress in power* with new outdoor construction, reheat cycle and American Blower Fans

SINCE THE second world war, the Long Island Lighting Company has spent millions on expansion — over $150,000,000 on electrical facilities alone. Operating efficiencies have gone up.

The use of the reheat cycle and high steam pressures and temperatures have cut fuel costs. New outdoor-type generating units permitted greater flexibility and saved in construction costs. However, these new units, using American Blower Forced and Induced Draft Fans, have provided more than flexibility and savings: they are also free from objectionable noise.

When it comes to air handling equipment, leading power and industrial plants prefer American Blower equipment for its quiet, dependable operation, for indoor as well as outdoor-type installations.

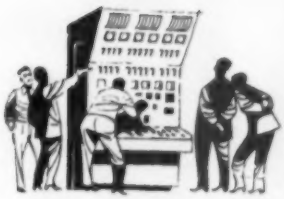
Whether *your* modernization or expansion plans call for Mechanical Draft Fans, Fly Ash Precipitators, Dust Collectors, Heavy Duty Steam Coils or Gyrol Fluid Drives for boiler feed pump and fan control — profit by discussing your needs with an experienced American Blower representative. Call your American Blower Branch Office, today, or write us direct.

AMERICAN BLOWER CORPORATION, DETROIT 32, MICHIGAN
CANADIAN SIROCCO COMPANY, LTD., WINDSOR, ONTARIO
Division of American Radiator & Standard Sanitary Corporation

AMERICAN BLOWER

Serving home and industry: AMERICAN-STANDARD • AMERICAN BLOWER • CHURCH SEATS & WALL TILE • DETROIT CONTROLS • KEWANEE BOILERS • ROSS EXCHANGERS • SUNBEAM AIR CONDITIONERS

Louisiana Power & Light Company's third unit at Ninemile Point Plant designed by Ebasco Services, Incorporated with Instrumentation and Control by Hays.



MORE AND MORE **CENTRAL STATIONS** ARE SELECTING **HAYS** INSTRUMENTS AND CONTROL

New ideas in instrumentation and control featured in outdoor boiler plant

MEET DEMANDS OF LATEST TYPE BOILER IN SPACE SAVING, GREATER SPEED OF RESPONSE, ALTERNATE FUEL FIRING.

Practically every detail of the third unit of Louisiana Power's new Ninemile Point generating plant is of the newest design. An all-weather outdoor boiler with Hays electric type combustion control—gas fired, with provisions for "stand-by" oil firing—will produce 1,000,000 lbs. of steam per hour, superheated and reheated to 1,005° F. . . . adding a capability of another 135,000 KW to Louisiana's power program.

On outdoor boilers electrically operated combustion control is especially preferred because it doesn't require expensive compressors and dryers, allows maximum freedom in the location of the control room.

To answer operators' demands for more instruments in less space, Louisiana Power is installing a miniature remote control station. This Hays benchboard, which is four feet wide contains all important remote control elements—manual adjustments for the boiler, turbine and generator.

For faster speed of response and greater accuracy a number of Hays electronic instruments are being installed. Among these are—electronic mercury-less flow meters and 3 element electronic feedwater control.

Among the central stations recently selecting Hays instrumentation and control are: Jersey Central Power and Light Co., Northern Indiana Public Service Co., Central Illinois Electric and Gas Co., St. Joseph Power and Light Co., Crawfordsville Power and Light Co.

Write for Hays Boiler Plant Instrumentation Bulletin 54-605-83.

THE **hays** CORPORATION

MICHIGAN CITY 1, INDIANA

Automatic Combustion Control • Veriflow Meters and Veritrol • Electronic Oxygen Recorders • CO_2 Recorders Boiler Panels • Gas Analyzers • Combustion Test Sets Draft Gages • Electronic Flowmeters • Miniature Remote Indicators • Electronic Feed Water Controls

Yes, a Straw Man...Often useful in real estate transactions, he represents the extreme opposite from the help you need for perfect piping when high temperature, high pressure or corrosion is involved. *Remember* to enlist Mitchell "know-how" in prefabricating and erecting . . . and then *forget* your piping.

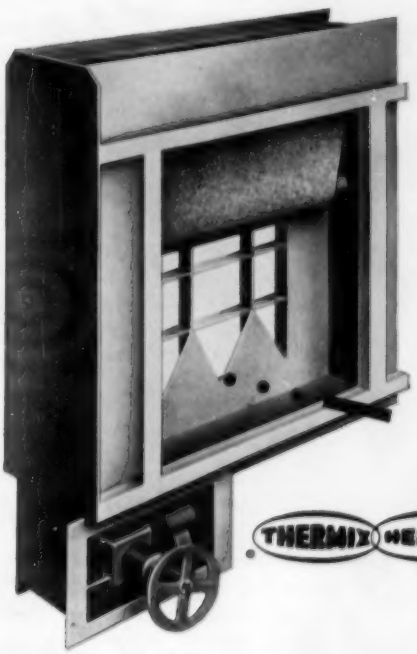
W. K. MITCHELL & CO., INC.
2946 Ellsworth Street, PHILADELPHIA 46, PA.

WESTPORT JOINT
(PATENTED)

MITCHELL PIPING
SINCE 1899

PIPING FABRICATORS AND CONTRACTORS

Only a Heacon Damper offers you this



"V" The V that gives you accurate control in the lower flow increments

Heacon Dampers provide the only solution to accurate flow control. With a background of over a decade of application to specialized problems, Heacon Dampers are accepted by engineers as the only means of accurate flow control, particularly in the lower flow increments.

V-porting is the secret. Heacon Dampers may be designed with V-porting to produce practically any flow characteristic from zero to 100%. With conventional dampers barely cracked, a flow of 10 to 20% or more is immediately released with resultant flow control problems in the entire system.

Heacon Dampers are a radical departure from normal damper construction. Consisting of supporting grill, sealing strip and flexible curtain of woven blue asbestos, metal or other suitable material as determined by the application, Heacon Dampers are recommended for use where these two factors, among others, are of major importance:

1.—Accurate control and ease of operation by either manual or mechanical means.

2.—Positive, tight seal when damper is closed.

The Thermix Corp., Project Engineers for Heacon Dampers are specialists in the application of this damper to your particular requirements. Why not call their engineers today.

Project Engineers

THE THERMIX CORPORATION
GREENWICH, CONN.

(OFFICES IN 38 PRINCIPAL CITIES)

Canadian Affiliates: T. C. Chown, Ltd. 1440 St. Catherine St. W., Montreal 25, Quebec. 983 Bay St., Toronto 5, Ontario, Canada

Can I use this sheet packing on hot oil lines, too?
Johns-Manville
SERVICE
Sure J-M Service Sheet is equally good for oil, steam and gas lines!

Your J-M Packings Distributor can tell you why this quality sheet packing has maintained such an excellent reputation for over 35 years

Where it's used: Every industrial plant can use J-M Service Sheet Packing to advantage. It's the favorite packing of thousands of plant engineers and maintenance men. Both versatile and dependable, Service Sheet makes a tight, long-lasting seal against superheated steam, air, gas, water, hot oil and ammonia, as well as many acids and chemicals.

What its advantages are: J-M Service Sheet is a quality packing, made of selected long-fibre asbestos bonded with heat-resisting compounds. It is graphited on one side to permit breaking a joint without destroying the gasket. The ungraphited side is ruled into one-inch squares to speed cutting and reduce waste. And . . . you can order it in large economical quantities because J-M Service Sheet will not dry out in stock!

How it is furnished: Service Sheet is supplied in sheets 54″ x 63″, 36″ x 126″, 36″ x 63″, and 54″ x 126″ sheets in thicknesses of 1/64″ to ¼″ and 108″ x 126″ sheets in thicknesses of 1/32″ to ¼″. It is also furnished as cut gaskets in standard and special shapes. See the J-M catalog for further details.

Your J-M Packings Distributor carries complete stocks of J-M Service Sheet and other quality Johns-Manville Packings. He can help you choose the right packing for your application. Write him for complete information and copy of folder PK-19A, "Thousands of Plants Rate It Tops." Or address Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay Street, Toronto 1, Ontario.

JM PRODUCTS

Johns-Manville PACKINGS & GASKETS

STAINLESS-CLAD STEEL DEFIES HANGUPS AND CORROSIVE WEAR

Two boilers at Salem Harbor Station are fed by stainless-clad steel bunker noses and pipes. No hangups or repairs have been reported in two years of operation.

In September 1952, the Salem Harbor Station of the New England Electric System went on the line. Rated as one of the most efficient stations in the nation, it has had two years of trouble-free operation. Stainless-clad steel figures directly in the exceptional performance of the interior coal handling equipment. No hangups or maintenance problems have occurred.

At Salem Harbor, stainless-clad was used at every point of extreme wear. The corrosive and abrasive effects of wet coal were virtually eliminated at key points. Four bunker noses and feed pipes were made of ⅜" stainless-clad, hoppers used 5/16" and ¼" clad, and chutes leading to the pulverizers are ¼" clad.

Stainless-clad steel—a layer of solid stainless steel integrally and permanently bonded over its entire surface to a strong, low-cost carbon steel backing plate—was chosen here for its twofold economy: low initial cost and minimum maintenance. Its smooth surface defies hangups and, with hard use, develops a mirror-like finish. It can extend the service life of coal handling equipment through the useful life of the boiler.

If you would like detailed information, write for Bulletin 740. In addition, our Technical Service Department is available to work with your equipment builders and engineers in putting stainless-clad steel to work for you. If you would like the names of qualified equipment builders, write to the Manager, Marketing Service, 684 Lukens Building, Lukens Steel Company, Coatesville, Pennsylvania.

LUKENS **CLAD STEELS**

STAINLESS-CLAD · NICKEL-CLAD · INCONEL-CLAD · MONEL-CLAD

PRODUCER OF THE WIDEST RANGE OF TYPES AND SIZES OF CLAD STEELS AVAILABLE ANYWHERE

HALL INDUSTRIAL WATER REPORT

Hall Laboratories, Inc.—A Subsidiary of Hagan Corporation, Pittsburgh, Pa.

Volume 3 | FEBRUARY 1955 | Number 1

It Takes a Lot of Water Conditioning To Manufacture an Automobile

And the water problems in some two hundred auto manufacturing plants serviced by Hall Laboratories are almost as varied as the number of operations required to put a new automobile on the highway.

Service records of the Hall engineers tell the story:

In the Boiler House:

Automotive Hardware Plant No. 62
Report by H. A. Reda

No. 2 Boiler (over 30 years old) has been baffled as per our recommendations to reduce carry-over. In line with mechanical changes, continuous blowdown systems have been installed on all of the boilers so that a control program for regulating the rate of blowdown can be set up.

Units which had been opened reflected considerable improvement in sludge distribution. These improvements were realized not only because of mechanical changes, but also by the very close control maintained over boiler-water conditioning.

In Plant Processing:

Metal Fabricating Plant No. 83
Report by J. A. Ivancic

Processed parts of sheet aluminum came through cleaning with electrical resistance so high that welding of the finished product was difficult. Resistance amounted to hundreds of microohms on the surfaces instead of the maximum acceptable resistance of 35 microohms. Plant men suspected change in water supply might be responsible.

Working with the capable plant engineer, our process specialist Kurt Albrecht spotted other possible sources of trouble when he was called in to study the problem. In the deoxidizing bath, conditions were such that appreciable silicic acid salts could plate out on the aluminum. At the final rinse stage, acid dosage did not compensate for the wide variations in alkalinity of different water supplies. The type of wetting agent being used in this operation further contributed to the surface resistance of the finished parts. Finally, drying methods evaporated rather than removed rinse solution, leaving solids of high resistance.

Close control of deoxidizing is now being maintained by the improved methods recommended. Constant use of deionized water and elimination of acid feed (carry-over from deoxidizing now provides the correct pH of solution) minimized the pick-up of solids in the final rinse. Blasting with compressed air to remove rinse water further reduced the surface resistance of the parts. More reliable measurement of resistance has resulted from an improved method.

Plant men informed us that Kurt Albrecht got them squared away ok on their aluminum cleaning problem.

In the Condensate Return System:

Engine Plant No. 142
Report by R. R. Christian

Tank engine plant showed marked corrosion reduction during a test period feeding a maximum of 2.5 ppm. of Hagafilm. Comparative tests showed corrosion reduction of 98 percent in the boiler house lines, and 89 percent in the main manufacturing building.

In Plant Water and Cooling Systems:

Automotive Assembly Plant No. 7
Report by F. R. Duesing

Major cause of production delays in this assembly plant was frequent burning out of tips on water-cooled spot welding guns. Tips were plugging up with dense hard material, shown by lab tests to be corrosion product, calcium carbonate scale, and some asbestos dust from a neighboring plant taken into the system by way of the cooling tower.

Threshold treatment, using the new Calgon® Composition T, which allows very low phosphate reserve and a comparatively broad pH range, eliminated scale formation and corrosion. But the asbestos dust being caught in the cooling tower and so introduced into the recirculating system still plugged the welding gun tips. Filters were recommended and installed to handle only the water supplying the welding guns.

Combination of chemical and mechanical treatment has now eliminated burn-outs.

Automotive Assembly Plant No. 34
Report by L. P. Dougherty

Experience on a previous job at an assembly plant serviced by Hall engineer S. R. Osborne led the power plant engineer to start a new tank plant off right by treating well supply with glassy phosphate, and a closed cooling system with chromate.

At the new plant the treatment of well water and the recirculating system is being carried out without a hitch.

* * *

Manufacturing automobiles is the business of all these plants. Hall Laboratories' part in getting the cars on the road is to help the industry to obtain the most service from the millions of gallons of water being used in its plants.

Industrial Water Problems Require Special Handling

There are no "stock answers" to industrial water problems. For information, write, wire or call Hall Laboratories, Inc., Hagan Building, Pittsburgh 30, Pa.

Water is your industry's most important raw material. Use it wisely.

The New S·E·CO. Coal Valve
Can Eliminate Your Coal Valve Headaches

FOR EXAMPLE . . . it has *self-cleaning*, coined, ladder racks that cannot become clogged with coal, even on jobs having internal pressure. This feature alone can eliminate hours of time spent cleaning coal from the valve body, racks and pinions so that you can operate it.

. . . the pinions are also of *self-cleaning* design, located *above* the gate, an exclusive S-E-Co. design feature. This position helps keep the ladder racks clean and assures positive tooth engagement. This, together with the new husky sized racks, can eliminate your troubles with tooth breakage and subsequent time consuming repairs.

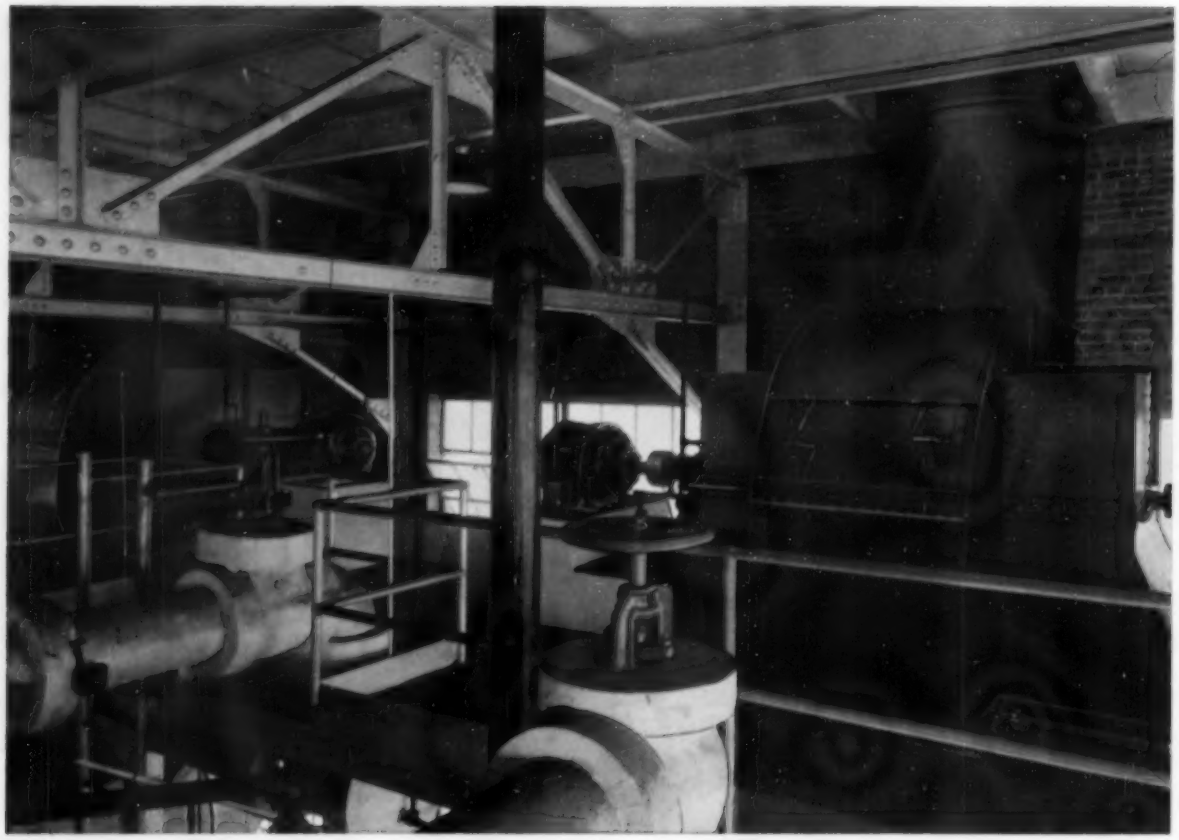
. . . large, 2-5/16" diameter, rollers, equipped with ball bearings, support the gate making sure it will move easily. These rollers have stainless steel shells to combat corrosion. Felt grease seals and stainless steel grease retainers with fittings for pressure lubrication insure their long life.

Dependability, minimum maintenance requirements and ease of operation are built into each S-E-Co. Coal Valve. Write for our new Bulletin #97 or for a local representative to call and assist you select valves to replace those that are not giving satisfactory service.

SPECIALISTS IN
BUNKER TO PULVERIZER AND
BUNKER TO STOKER EQUIPMENT

STOCK Equipment Company

745- C HANNA BLDG., CLEVELAND 15, OHIO



EVERY TON OF FUEL YOU BURN TAKES 12 TONS OF AIR

See P. 545 of FAN ENGINEERING, 5th Edition, chapter on Combustion and Mechanical Draft.

Since approximately twelve pounds of air must pass through your boilers to burn a pound of combustible, your draft department is no place to cut corners. Also, today's high pressure requirements for super-heated steam, plus air preheaters and flue gas cleaning equipment in the system, place extremely heavy loads on the fans. It calls for the best fans you can get!

This is why so many power plant operators use "Buffalo" Forced Draft, Induced Draft, Gas Recirculating, Primary Air Fans and Overfire Blowers. They're built with one thought: to deliver the draft your fuel requires, with the lowest possible maintenance costs, and the shortest and fewest possible draft timeouts. Have us mail you Bulletin 3750 and see why your best choice is "Buffalo".

**The "Q" Factor — the built-in Quality which provides trouble-free satisfaction and long life.*

SPECIFY

"Buffalo" THE DRAFT FANS with the "Q" Factors

- Built to stand up
- Easier to service
- High in efficiency
- Performance characteristics to meet pressure demands in modern steam generation practice

BUFFALO FORGE COMPANY

170 MORTIMER STREET BUFFALO, NEW YORK

PUBLISHERS OF "FAN ENGINEERING" HANDBOOK

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

Sales Representatives in all Principal Cities

VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT EXHAUSTING FORCED DRAFT COOLING HEATING PRESSURE BLOWING

For Features that Mean Long Valve Life and Low Cost Service Get this ALL-Purpose Edward Forged Steel Globe Valve

Edward Fig. 444-448 series, built in sizes ¼ to 2 in. inclusive . . . forged steel globe and angle . . . 600 and 1500 lb sp . . . bolted or union bonnet . . . screwed or socket welding ends . . . Fig. 448 illustrated.

CHECK THESE Big 7 FEATURES

- ✓ Hard bronze yoke bushing to prevent stem seizing or galling . . . lock welded to yoke
- ✓ Packing is Edward EValpak . . . heat resistant, water-proofed and die molded for long service
- ✓ Disk of EValloy 13% chromium or Stellite . . . slotted or disk nut type . . . self centering
- ✓ Tight, easily accessible bolted or union bonnet joint . . . with Ironkote gasket of 90 Brinnel max. hardness for leak-proof joint
- ✓ Heat treated forged steel inclined stem globe type body for lowest pressure loss
- ✓ Built-in pressure-tight backseat . . . permits repacking under pressure
- ✓ Roomy forged yoke . . . plenty of finger space for repacking
- ✓ Strong forged gland bolts . . . plated for long thread life

EDWARD VALVES, INC.
Subsidiary of Rockwell Manufacturing Company
1206 West 145th Street, East Chicago, Indiana
EAST CHICAGO, INDIANA

Please send literature covering your Fig. 444-8 series all-purpose forged steel valves.

Name_____

Company_____

Position_____

Address_____

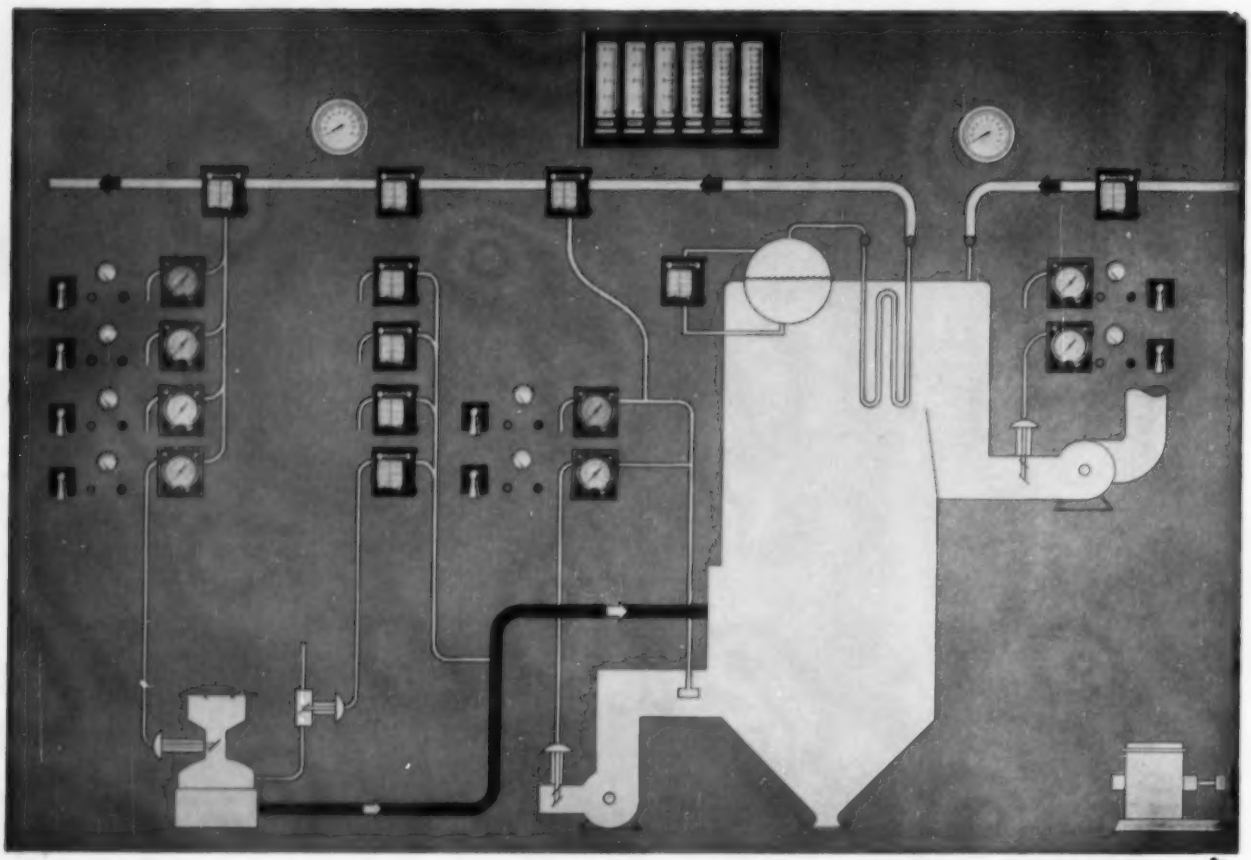
City_____ Zone____ State_____

Another Product

Edward Valves, Inc.

Subsidiary of ROCKWELL MANUFACTURING COMPANY
1206 WEST 145th STREET, EAST CHICAGO, INDIANA
EAST CHICAGO, INDIANA

TO REDUCE



*

COPES-VULCAN OFFERS ALL THESE CONTROLS

COMBUSTION

Combustion may be controlled from steam flow-air flow, or by fuel-air-ratio method. Instrumentation of the most modern design by Taylor assures fast response, accurate control and utmost dependability.

FEED WATER

Boiler Feed Water may be controlled from three, two or one influences. Feed water control systems may have *instrumentation by Taylor* (Type 3-L, Bulletin 1013), or be electrically or mechanically operated.

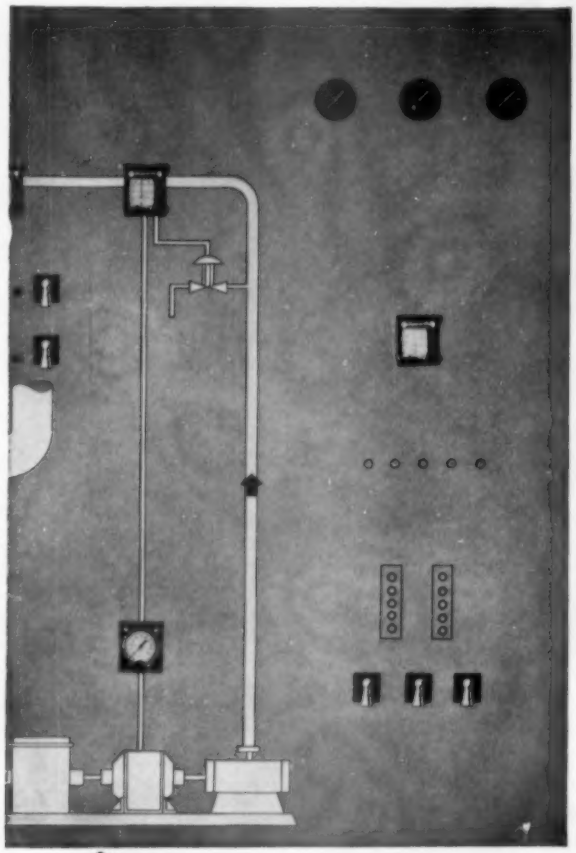
PRESSURE AND TEMPERATURE CONTROL

Pressure reducing valves to meet any need. Steam temperature control may be from three or two influences, using burner or damper positioning, gas recirculation, direct water spray or heat exchanger.

SOOT BLOWING

Full automatic-sequential control may be part of main panel or set up on separate panel. Individual push button control available. For smaller boilers there are manually operated units in several types.

STEAM COSTS



*Modernize With *C·V+T Boiler Control

WHEN you plan to modernize your power facilities, check into the many advantages offered by Copes-Vulcan Boiler Control.

From one dependable source, you can get modern combustion control *with instrumentation by Taylor*, precise feed water control, accurate steam temperature control and automatic cleaning of heat-transfer surfaces.

Remember, too, Copes-Vulcan assumes full responsibility for service wherever needed—for the life of your installation.

Ask Copes-Vulcan engineers for recommendations on how to reduce your steam costs. Write for Bulletin 1007-A.

*C·V+T=BBC

COPES·VULCAN+*Taylor*=BETTER BOILER CONTROL

COPES-VULCAN DIVISION

CONTINENTAL FOUNDRY & MACHINE COMPANY

ERIE 4, PENNSYLVANIA

COPES VULCAN BOILER CONTROL

WITH INSTRUMENTATION BY *Taylor*

BRINGING YOUR
COAL HANDLING COSTS

Down to Earth

Concrete Silo Storage with live storage shelf, track hopper, double-chain bar feeder, centrifugal discharge bucket elevator, scale and monorail bucket.

Tile Silo Storage with track hopper, bar feeder, bucket elevator, 2000 lb. weigh larry.

Cylindrical Steel Tank Storage with feeder and conveyor.

Suspended Steel Bunker Storage showing bunker and weigh larry.

When coal handling costs are too high for comfort, remember Gifford-Wood's 4-basic design story. Each of these storage designs—concrete silo, tile silo, cylindrical steel tank and suspended steel bunker—are carefully engineered to meet specific limitations of climate, capacity, space available and cost. The combination of extensive engineering experience and well known manufacturing ability assures installations of highest possible operating efficiency at reasonable cost.

A Gifford-Wood engineer, thoroughly familiar with coal handling problems, is at your service. Let him study your needs and recommend a G-W system that will both simplify the operation and reduce your costs.

4

BASIC G-W WAYS TO CUT COAL HANDLING COSTS

1. Reinforced Concrete Silo Storage
2. Vitrified Tile Silo Storage
3. Cylindrical Steel Tank Storage
4. Suspended Steel Bunker Storage

Bulletin No. 300 describes, with illustration and working drawing, these 4 basic G-W types of handling systems. Write today for your copy.

GIFFORD-WOOD CO.

SINCE 1814
Hudson, N. Y.

NEW YORK 17
420 LEXINGTON AVENUE

CHICAGO 6
565 W. WASHINGTON STREET

ST. LOUIS 1
RAILWAY EXCHANGE BUILDING

6378

G-W HANDLES IT . . . faster • easier • cheaper

a practical answer to

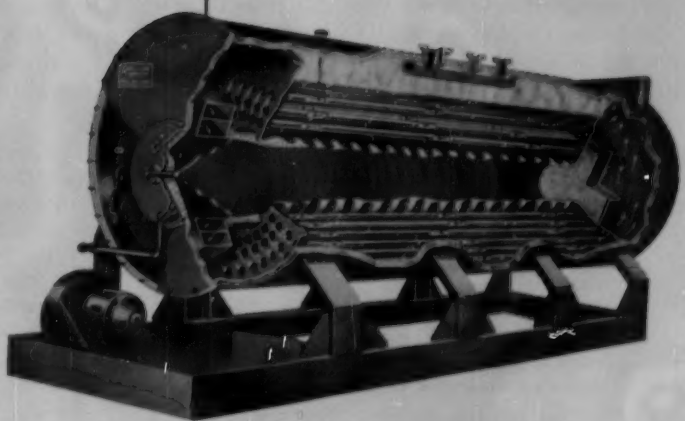
CARBOFRAX liner is made of 1¾"-thick segments of tile.

in steam generators

Here's how one manufacturer of package steam generators builds extra life into his units. He uses a 1¾"-thick lining of CARBOFRAX® silicon carbide tile to shield the metal surfaces at the mouth of the firing tunnel from the severe heat shock and corrosive action of the hot fuel gases as they blast from the burner tube.

Since CARBOFRAX refractories conduct heat nearly as rapidly as alloy steel (11 to 12 times as fast as fireclay), there's little or no interference with heat transfer in the area of the liner. As a matter of fact, the hot face of the CARBOFRAX tile actually helps get maximum fuel efficiency by improving combustion.

Ames Iron Works is one of many progressive builders of steam generating equipment who have recognized the wisdom of applying Super Refractories by CARBORUNDUM where combustion conditions are most severe. Wouldn't it pay you to consider these materials the next time one of *your* hot spots needs attention? Write today for our 32-page summary of Super Refractory applications in boiler trouble spots. Address Department E25, The Carborundum Company, Perth Amboy, New Jersey.



"Amesteam" generator is built by Ames Iron Works, Inc., Oswego, N. Y. The CARBOFRAX liner is used in all Ames generators rated 200 HP, or above, that burn heavy fuel oil.

CARBORUNDUM
Registered Trade Mark

A panel of 32 tubes, supported by strongbacks, is fed into a specially adapted press where, in one operation, the tubes of the entire panel are bent.

Here at the job site the panels are carefully stacked in proper sequence which greatly facilitates handling and erecting operations.

NOW WE'RE "PREFABBING" BIG

Developed by Combustion, this new erection technique is a significant step toward reduction of boiler erection time and cost. It makes obsolete the practice of erecting large steam generating units part by part and tube by tube. Instead, by prefabricating large assemblies in the C-E shops, the number of repetitive field erection operations is appreciably reduced.

No longer need waterwall tubes be erected one by one. By prefabricating waterwall tube sections into panels, substantial savings in time and money are achieved. Panels consisting of 32 or more tubes, ranging in length between 40 and 60 ft., are shaped, packaged and shipped as units to the job site. It makes no difference if the tubes are straight or have multiple or compound bends. They can be prefabricated and shipped in panels that are convenient to handle. Even complete burners and their adjacent waterwall tubes are shipped as assemblies.

The advantages of such construction are numerous. Some of the more significant are:—

1 Shop assembled in precision jigs, the lengths of the tubes in each panel are exact and uniform.
2 Tube bending operations in the shops are accomplished much quicker and with a high degree of uniformity.
3 Loading and unloading panels on railroad cars is much faster than handling individual tubes.
4 Since panels can be properly supported and compactly packed aboard freight cars, tube damage while in transit is minimized.
5 At the job site, paneled tubes can be stored compactly and neatly, thereby reducing the amount of storage space required.
6 Properly numbered panels are easy to find and the "needle in the haystack" process of finding individual tubes is eliminated.
7 The number of hoisting operations is greatly reduced and better use can be made of the hoisting facilities.
8 Handling time, from storage yard to final position in the boiler, is much shorter.
9 Furnaces can be closed in much more quickly.

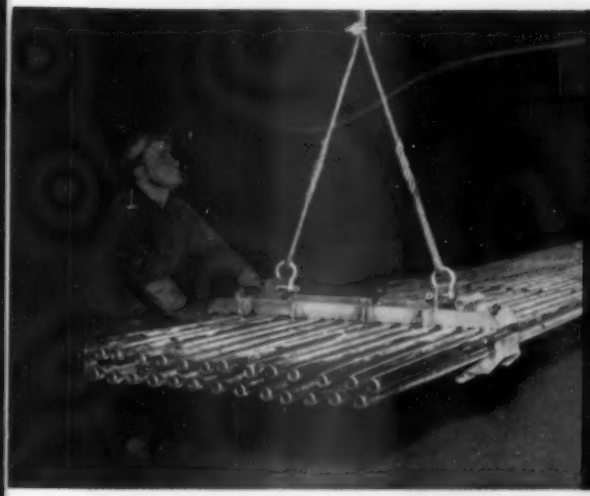
This advance in technique is still one more example of the continuing effort on the part of C-E to make good products better.

B-807

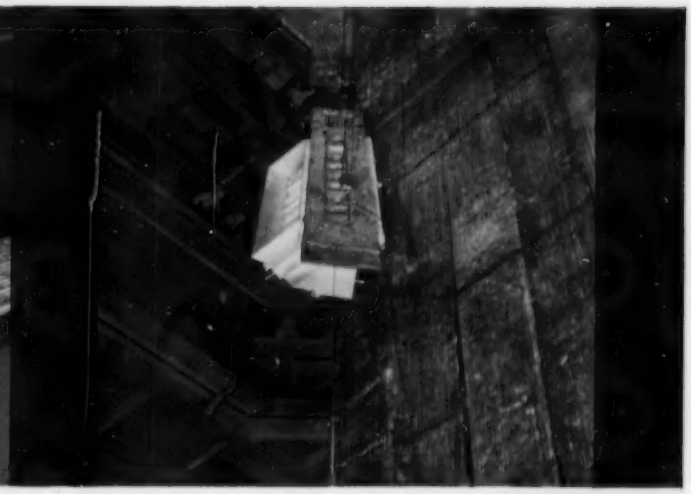
COMBUSTION ENGINEERING

Combustion Engineering Building • 200 Madison Avenue, New York 16, N. Y.

BOILERS, FUEL BURNING & RELATED EQUIPMENT; PULVERIZERS, AIR SEPARATORS AND FLASH DRYING SYSTEMS; PRESSURE VESSELS; AUTOMATIC WATER HEATERS; SOIL PIPE

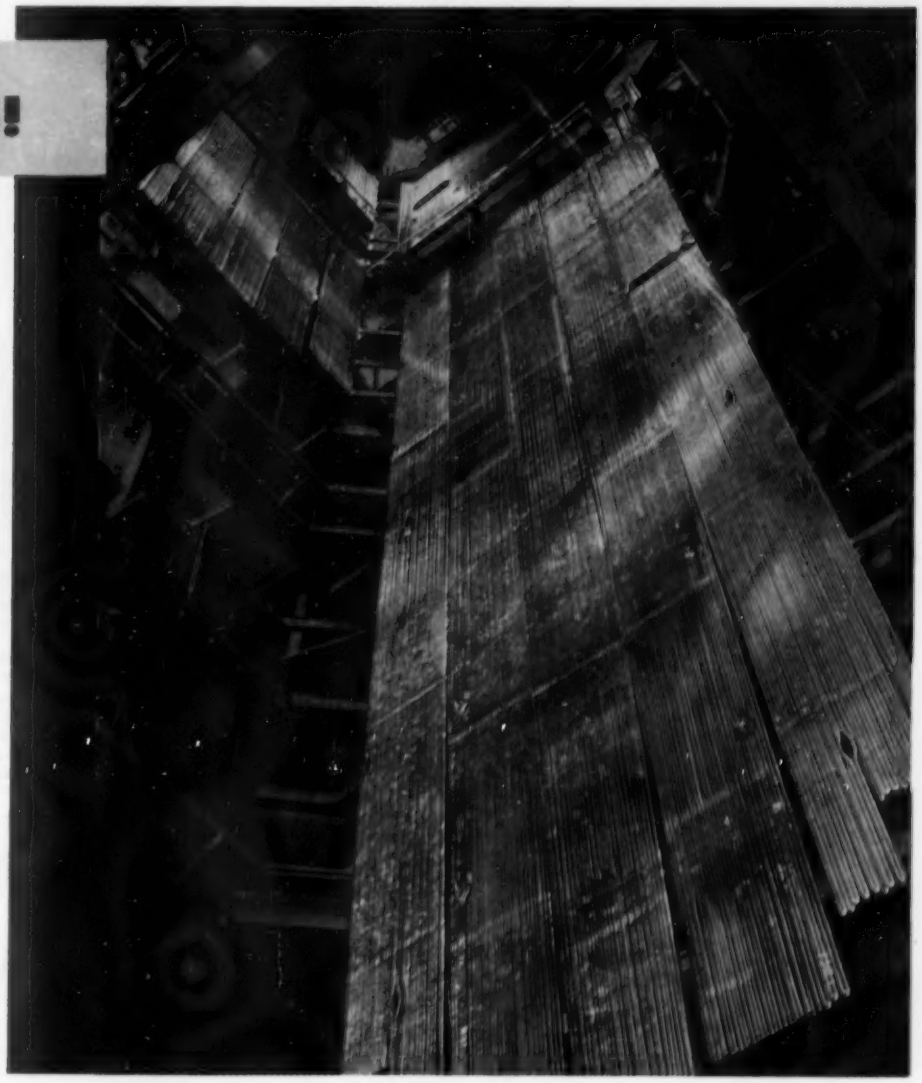


Separating and lifting jigs are in place on a panel about to be hoisted. Note that tube ends are accurately prespaced to facilitate welding.



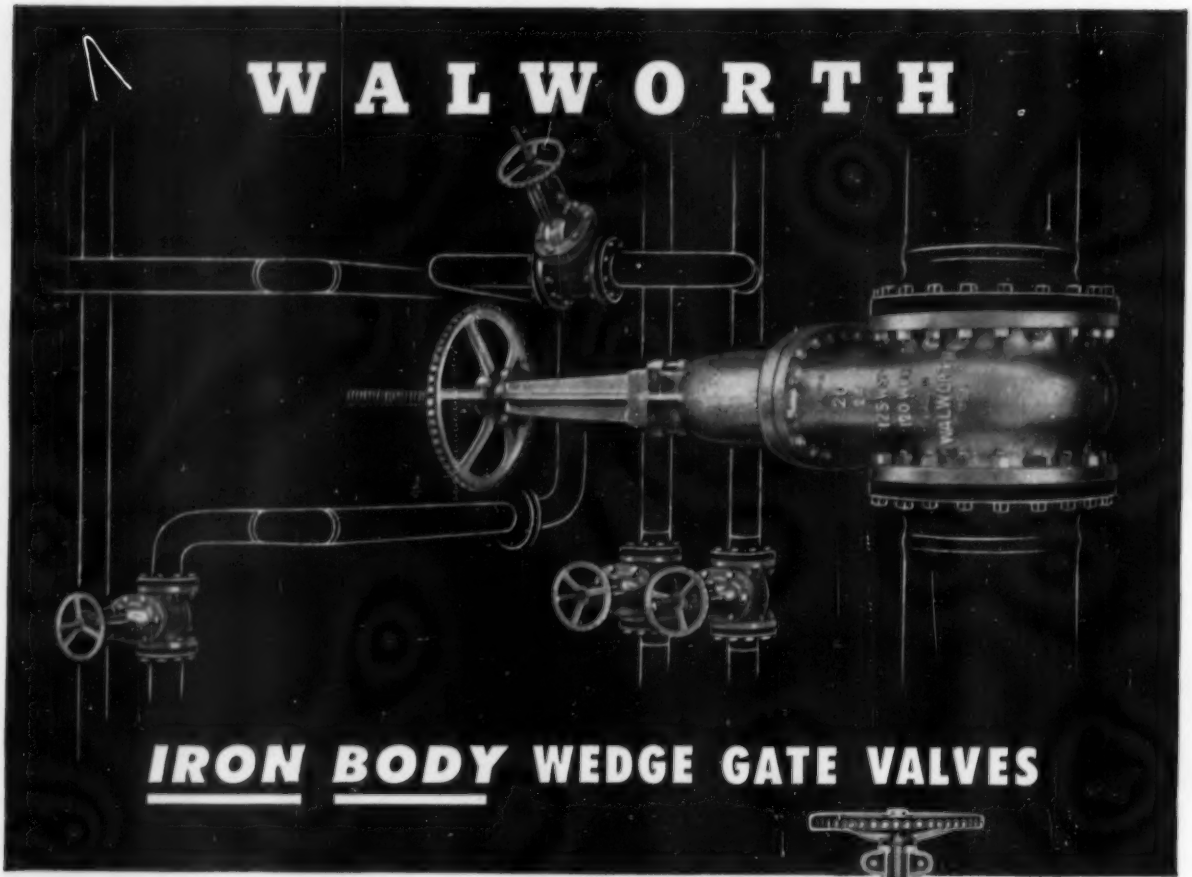
A corner assembly, which comprises a complete tangential burner unit with its waterwall tube panel, is raised into position.

BOILERS!



Thirty separate panels comprising nearly 1000 individual tubes are now in place. Only 30 hoisting operations were required.

WALWORTH



IRON BODY WEDGE GATE VALVES

Better because ...**The entire valve, from handwheel to seat rings, is ruggedly constructed to withstand rough and frequent usage. Body, bonnet, and yoke are sturdy castings with large radius fillets. Dimensions and drilling of end flanges are in agreement with American Cast Iron Flange Standards. Stiffening ribs connect end flanges with the body neck to maintain a rigid connection with piping.**

A wide range of Walworth Iron Body Wedge Gate Valves is available—through your Walworth Distributor—from which you can choose the right type to meet your most exacting conditions. Saddle-type valves as small as ¼-inch; low pressure valves for water and gas pipelines up to 36 inches.

Whenever you need valves and fittings, choose from complete lines—in a variety of metals—manufactured by Walworth. For more information, see your Walworth Distributor or write: Walworth Company, General Offices, 60 East 42nd Street, New York 17, N. Y.

Walworth No. 726F OS&Y (Outside Screw and Yoke) Iron Body Wedge Gate Valve. OS&Y valves are recommended for services where it is desirable that the line fluid does not come in contact with the stem threads. Note the swing-type gland-eye-bolts for easy repacking. Sizes 2 to 30 inches.

WALWORTH

Manufacturers since 1842

valves . . . pipe fittings . . . pipe wrenches

60 East 42nd Street, New York 17, N. Y.

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

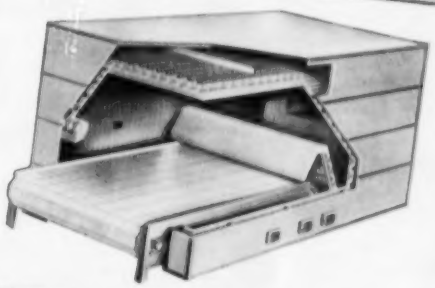
MOIST FUEL CELLS

An important application of B-L unit-suspended walls and arches is found in furnaces where a fuel with a high moisture content is burned. Although designed primarily for use in cane sugar countries for bagasse burning, these furnaces have proven so successful in other fields such as the burning of bark and wet wood refuse.

BIGELOW-LIPTAK *Corporation*

UNIT-SUSPENDED WALLS AND ARCHES

In Canada BIGELOW-LIPTAK OF CANADA, LTD. *Toronto, Ontario*



DRYER FURNACES

A tough assignment for a furnace is to stand up under the every-day beating of heat in drying applications. B-L's streamlined thin wall dryer furnace does it—cuts maintenance to boot. It furnishes heat for drying coal, sugar, salt, lumber, chemicals.

BIGELOW-LIPTAK *Corporation*

LOWEST MAINTENANCE

When you specify a B-L furnace enclosure you can be sure of long life and lowest possible maintenance. Intelligent engineering and top-quality materials provide the stand-up stamina that makes enclosures "tougher than blazes." Each unit is individually designed for the job. Write today for complete information.

Castable Linings

B-L's castable lining for oil refining furnaces provides a smooth monolithic wall capable of resisting abrasion and standing up under high heat demands. The construction is adaptable to catalytic regenerators, catalytic reactors, cyclones, stacks and other refinery equipment.

BIGELOW-LIPTAK *Corporation*

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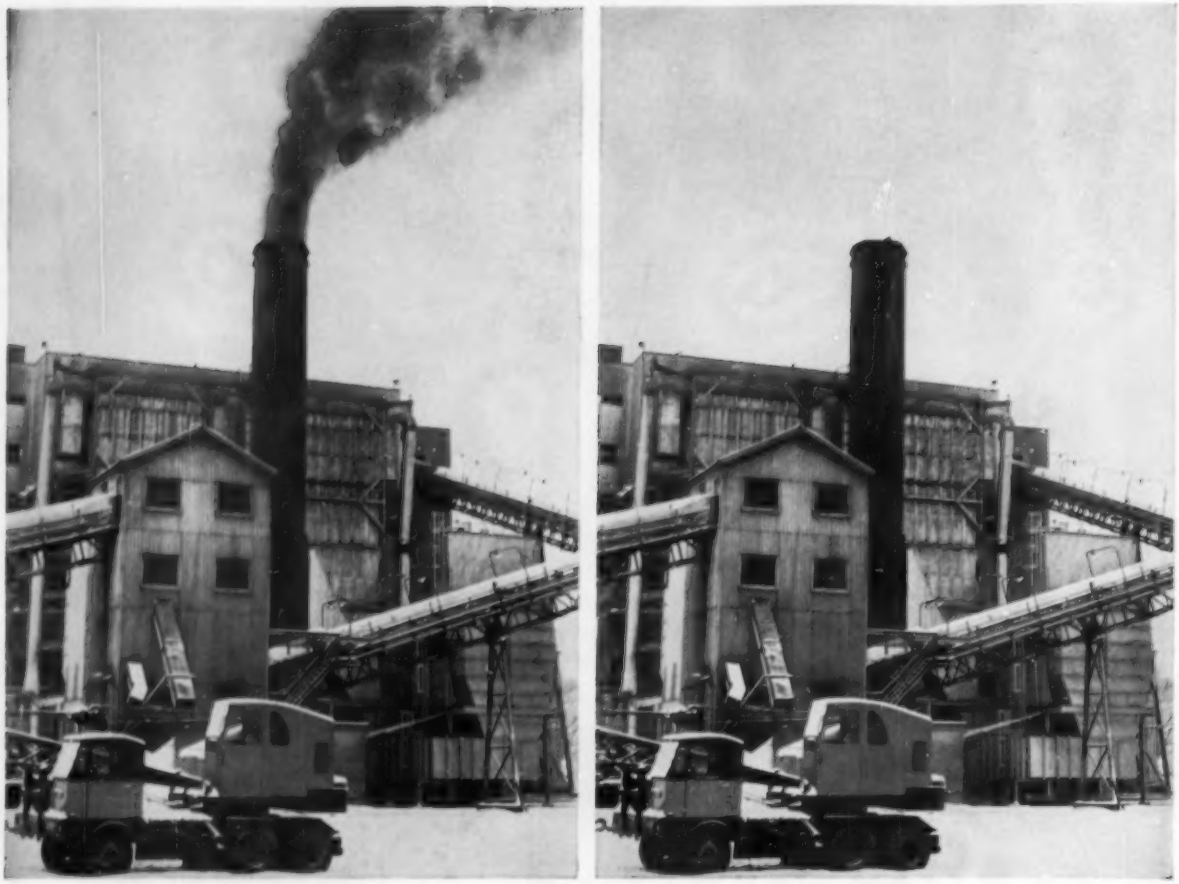
4193



Fly Ash Problem Solved By Central Station

This Pennsylvania utility felt that as long as you can *see* dirty stack discharge, you have a problem. To solve it, they decided to insist on fly ash collection equipment with very high efficiency.

The electrical precipitators they chose, which were placed after existing mechanical collectors, are Cottrells, designed and built by Research-Cottrell. Their effectiveness is demonstrated in the above unretouched photographs. At the left, the precipitators were turned off long enough to take the picture showing the volume of fly ash discharged by the boilers. At the right, the precipitators are turned back on. Stack discharge is visually clean.

This is another example of industry's trend toward establishing its own higher standards for nuisance abatement. Research-Cottrell, which has made more fly ash installations than any other company, cites the following comparison:

In the period from 1923 to 1939 only 11% of its power plant customers specified fly ash collection efficiency of 95 to 98%. In recent years, that 11% has risen to fully 90%.

One reason, of course, is the generally increasing emphasis on community relations. Another factor is that far-sighted companies are anticipating stricter smoke regulations. They are anxious to install equipment that will end their smoke problems now and also prevent such problems from occurring in the future.

Still another factor is this. In recent years, with modern coal pulverization and advanced boiler design, there has been an increase in the fineness of fly ash particles. This calls for the most efficient equipment available.

Read—in Bulletins FA and MI—about Cottrell equipment and the Research-Cottrell's MI Rapper. This device eliminates rapping puffs and enables the precipitator to maintain, continuously, its high collection efficiency. Write for your copies today.

RC-193

RESEARCH-COTTRELL, INC.

A WHOLLY OWNED SUBSIDIARY OF RESEARCH CORPORATION

Main Office and Plant: Bound Brook, N. J.

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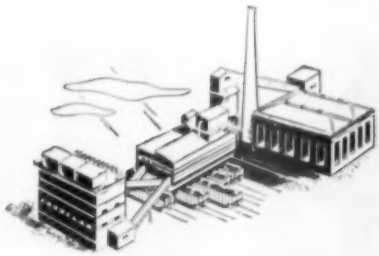
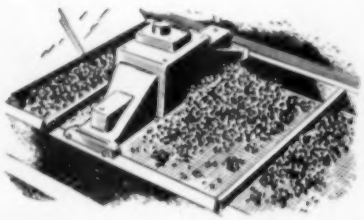
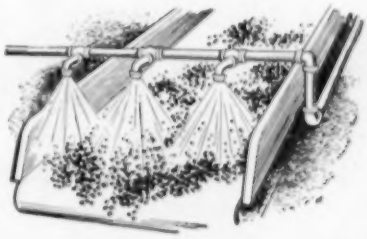
THERE'S NO BETTER STOKER COAL THAN BEACON PROCESSED POCAHONTAS



"LAUNDERED" PREMIUM COAL . . . Pocahontas—one of nature's finest coals—is made even better with careful processing in our modern cleaning plant.

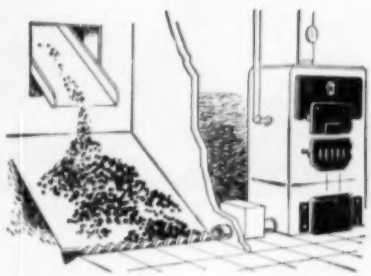


SIZED . . . Careful grading to specifications developed through years of research in our laboratory makes Beacon Coal ideal for efficient stoker operation.



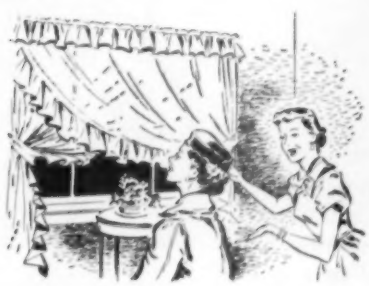
DUST-PROOFED . . . Complete cleanliness is insured by spraying with a special oil which spreads evenly to coat and dust-proof each piece. A luxurious touch!

ABUNDANT HEAT . . . Beacon Pocahontas Coal is naturally low in gas and tars, other impurities are washed away—result, a hot-burning, high-carbon fuel.

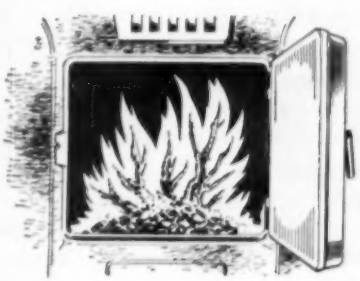


NO DUST NUISANCE . . . You'll find that delivery of a load of Beacon Stoker Coal doesn't cause dirt. Special cleaning and oil-coating processes keep dust down.

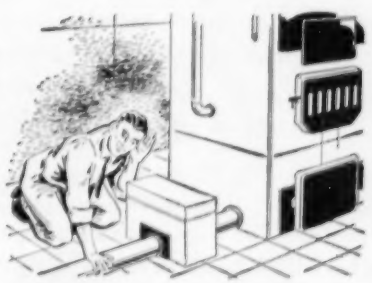
LESS ASH TO HANDLE . . . Beacon Pocahontas has little ash to start with—and less after it is cleaned. This ash fuses into firm, easily removed clinkers.



IT BURNS CLEAN . . . Beacon Pocahontas Stoker Coal is Low Volatile. In a properly operated stoker, it just doesn't make smoke or soot.



IDEAL COKING QUALITIES . . . Beacon Stoker Coal makes soft, porous, easily burned coke—assures good steady heat—quick response to the thermostat.



QUIET, SMOOTH STOKER OPERATION . . . Soft structure, uniform grading, permit coal to feed from bin to firebox quietly, without grinding, banging.

SPECIALLY PROCESSED TO GIVE MORE FOR EVERY FUEL DOLLAR

Beacon Processed Pocahontas Stoker Coal features mean comfort, convenience and economy for your customers—repeat sales for you!

EASTERN GAS AND FUEL ASSOCIATES

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Fresh Viewpoint on Dust Collection!

After seeing the daily operating records kept on Buell 'SF' Electric Precipitators and Cyclones by our customers . . . many executives and engineers have come away with a fresh viewpoint on industrial dust collection.

They have balanced initial cost against *actual* day-to-day results . . . they have investigated maintenance costs over as much as a 20 year period . . . they have compared designs with efficiency *maintained* over the years.

We invite you to look these daily operating records over yourself . . . there's Buell Equipment operating from Pennsylvania to Peru and a Buell Customer near you. We'll be glad to give you his name.

Meanwhile, get the complete facts about *all three* Buell Systems for industrial dust recovery. Our clearly worded Brochure—The Collection and Recovery of Industrial Dusts—will give you the whole story fast. Simply write Dept.70-B, Buell Engineering Company, 70 Pine Street, New York 5, N.Y.

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MECHANICAL ELECTRICAL

20 Years of Engineered Efficiency in

DUST COLLECTION SYSTEMS

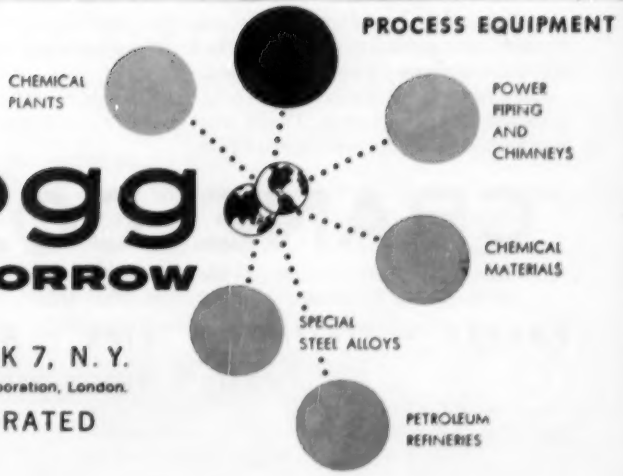
High Pressure Answer Men

Increasingly high pressures and temperatures used in processes today demand the most advanced engineering and metallurgical treatment of the piping and equipment to handle them. The M. W. Kellogg Company has earned a long-standing reputation in this specialized engineering area.

Largely responsible for M. W. Kellogg's position is the company's "Committee on Materials and Fabrication" which meets regularly to discuss developments of pure and applied research as they concern service experience, metallurgical progress, welding techniques, and improved methods of fabrication.

Composed of principal engineers from M. W. Kellogg's process engineering, mechanical engineering, and construction departments, as well as the Fabricated Products Division, this Committee benefits all of the company's activities and the facilities they offer in their respective fields.

The Committee on Materials and Fabrication is one reason why The M. W. Kellogg Company is recognized as the leader in the design and fabrication of piping, pressure vessels, heat exchangers, waste heat boilers, and process equipment requiring transient and maintained pressures and temperatures.



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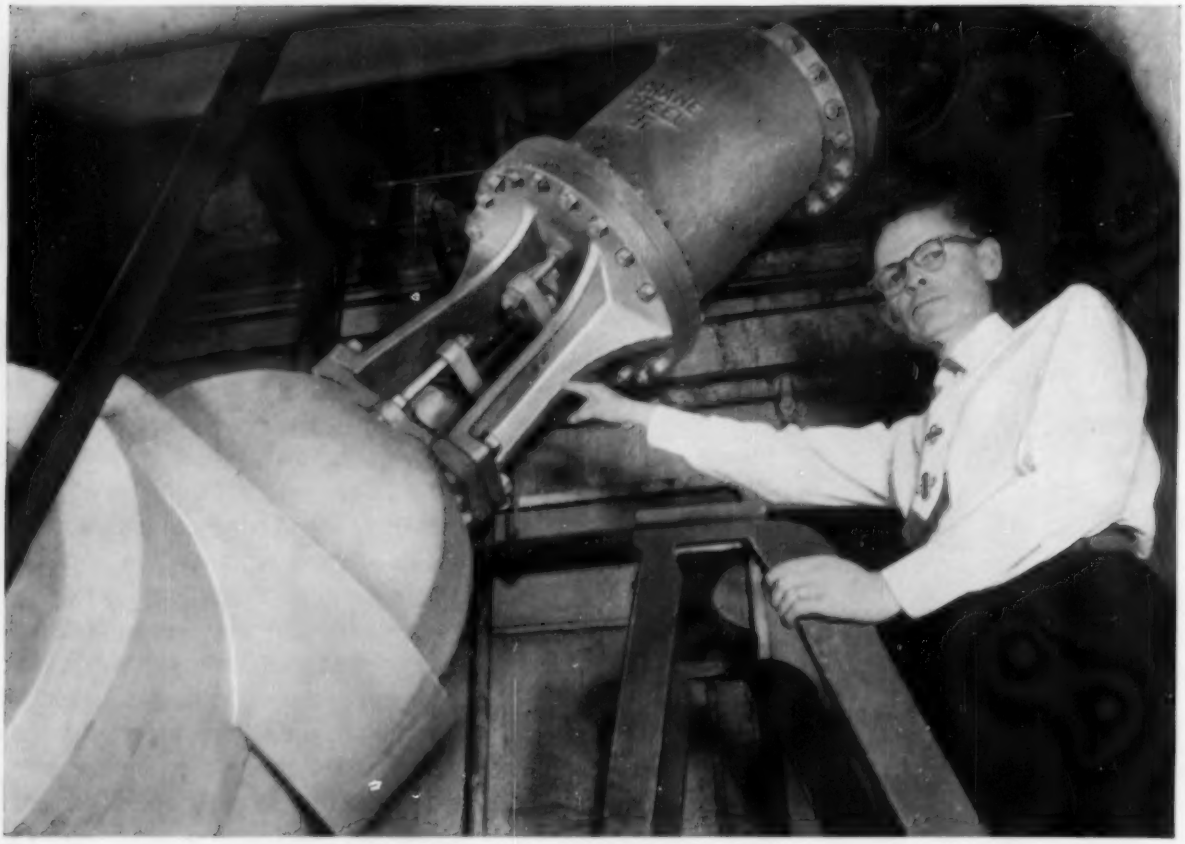


This CRANE VALVE begins new life after 37 years' service!

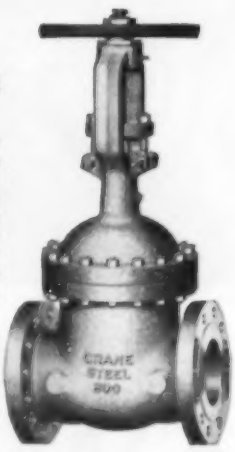
THE CASE HISTORY—World War One still raged when Cincinnati Gas & Electric Co. installed this Crane steel gate valve in 1917 at its Front & Rose Street Station. Ever since, it has safely controlled the main steam lead to No. 1 turbine—always making tight closure when needed—always responding smoothly to its hydraulic operator. For 37 years it has given such service with no more than routine maintenance—under operating pressure of 250 psi at 600 deg. F.

In 1954, the No. 1 turbine was renewed. The Crane steel valve—with complete confidence in Crane durable quality as demonstrated—was given limited preventive maintenance while down, and reinstalled in its original location.

Long life with minimum maintenance is a deeply rooted characteristic of Crane valves. That's what makes them industry's first choice today for low ultimate cost.

CRANE STEEL GATE VALVES
... a complete line

Here is steel casting at its best, by the pioneer in steel valve development. Here is value in durability . . . dependable operation . . . and in low-cost maintenance that sets Crane steel valves apart from the ordinary. They're made for every service—in all pressure classes and sizes. Consult your Crane Catalog or Crane Representative.



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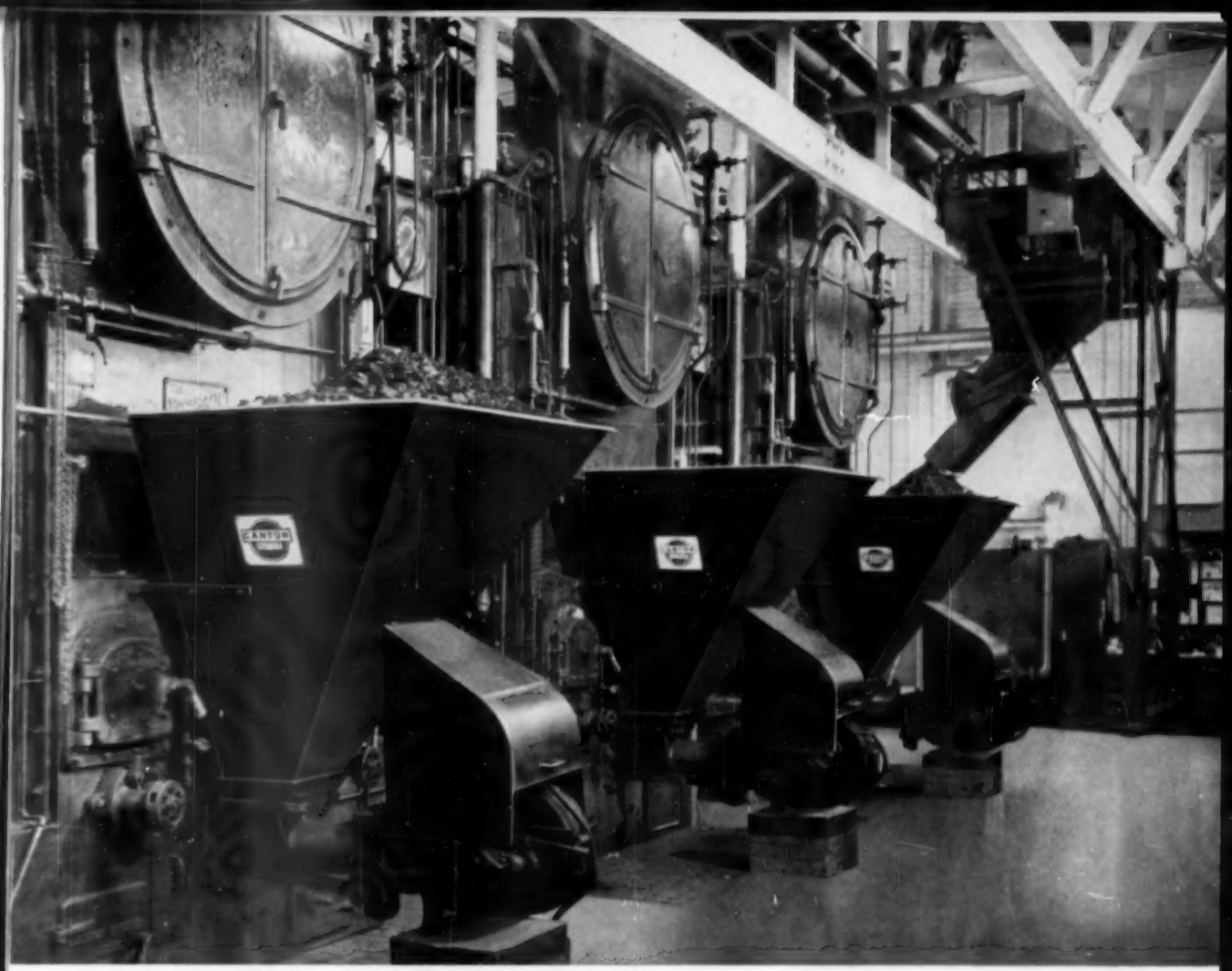

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facts you should know about coal

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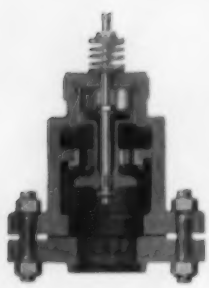
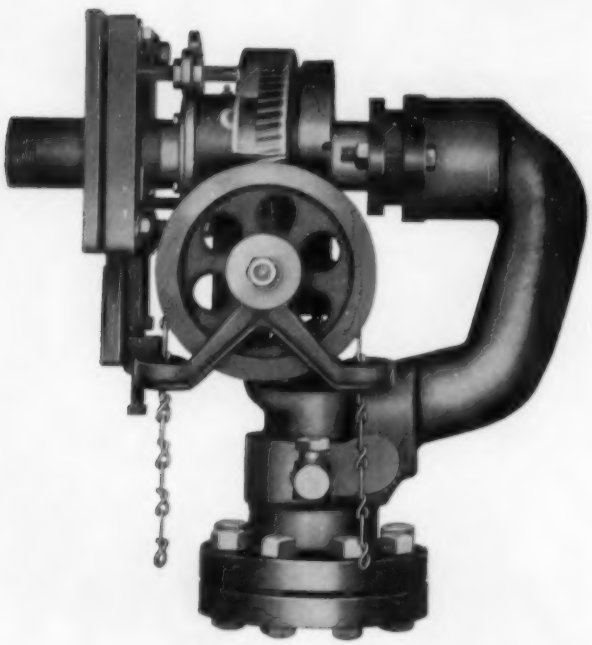


Bayer Balanced Valves are famous for their long life and continued tightness.



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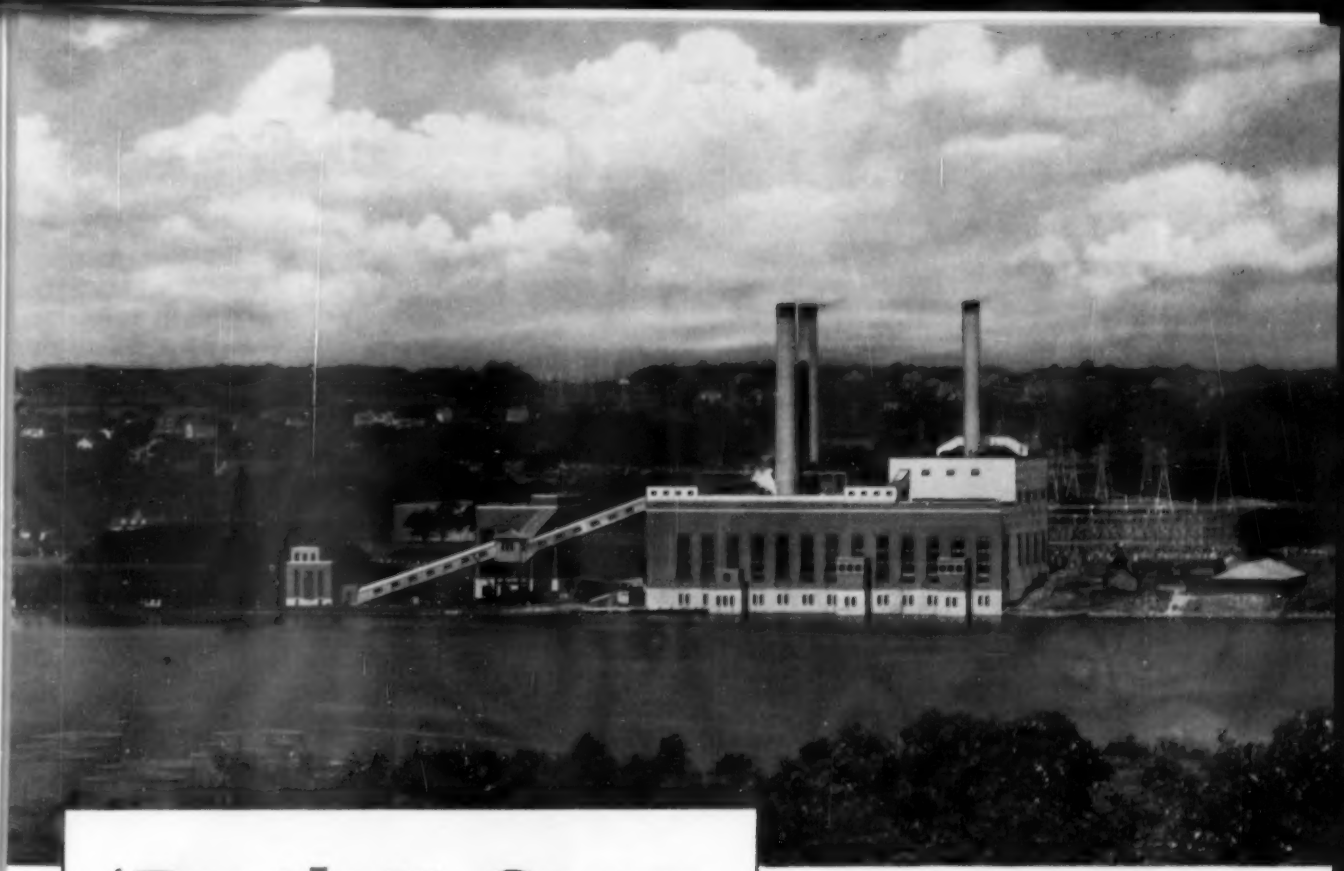
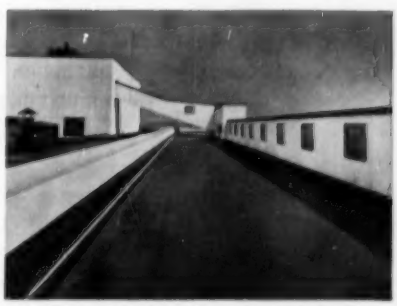


General View of Somerset Station
Montaup Electric Company
Stone and Webster Engineering Corp.
Consulting Engineers

Bartlett-Snow coal handling at Montaup

● The illustration above shows the Montaup Electric Company's Somerset Station after completion of a 60,000 K.W. extension that increased the total capacity of the plant to 210,000 K.W. The new coal handling equipment required — built and installed by Bartlett-Snow to Stone and Webster specifications — includes conveyors, weightometer and tripper. It connects into the old system at the south end of the plant, and is carried through a gallery built on the roof to discharge coal into the new bunker at the north end of the plant. For new plant projects, modernization programs, and additions and extensions to existing facilities, call the Bartlett-Snow coal handling engineers.

Bartlett-Snow Belt Conveyor Tripper
Over New Bunker



View of New Belt Conveyor Gallery
Built on Roof

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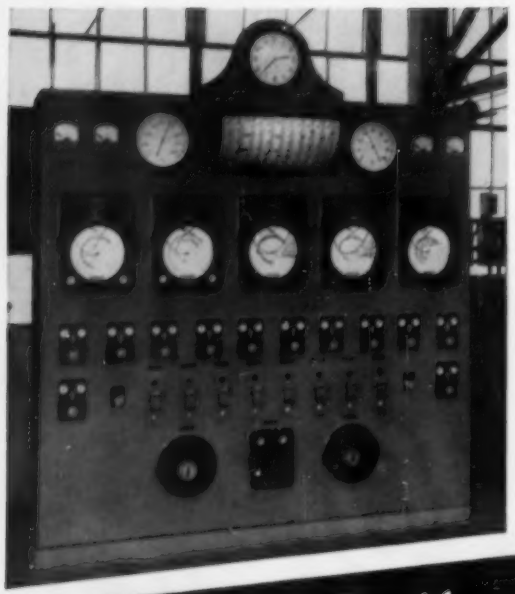

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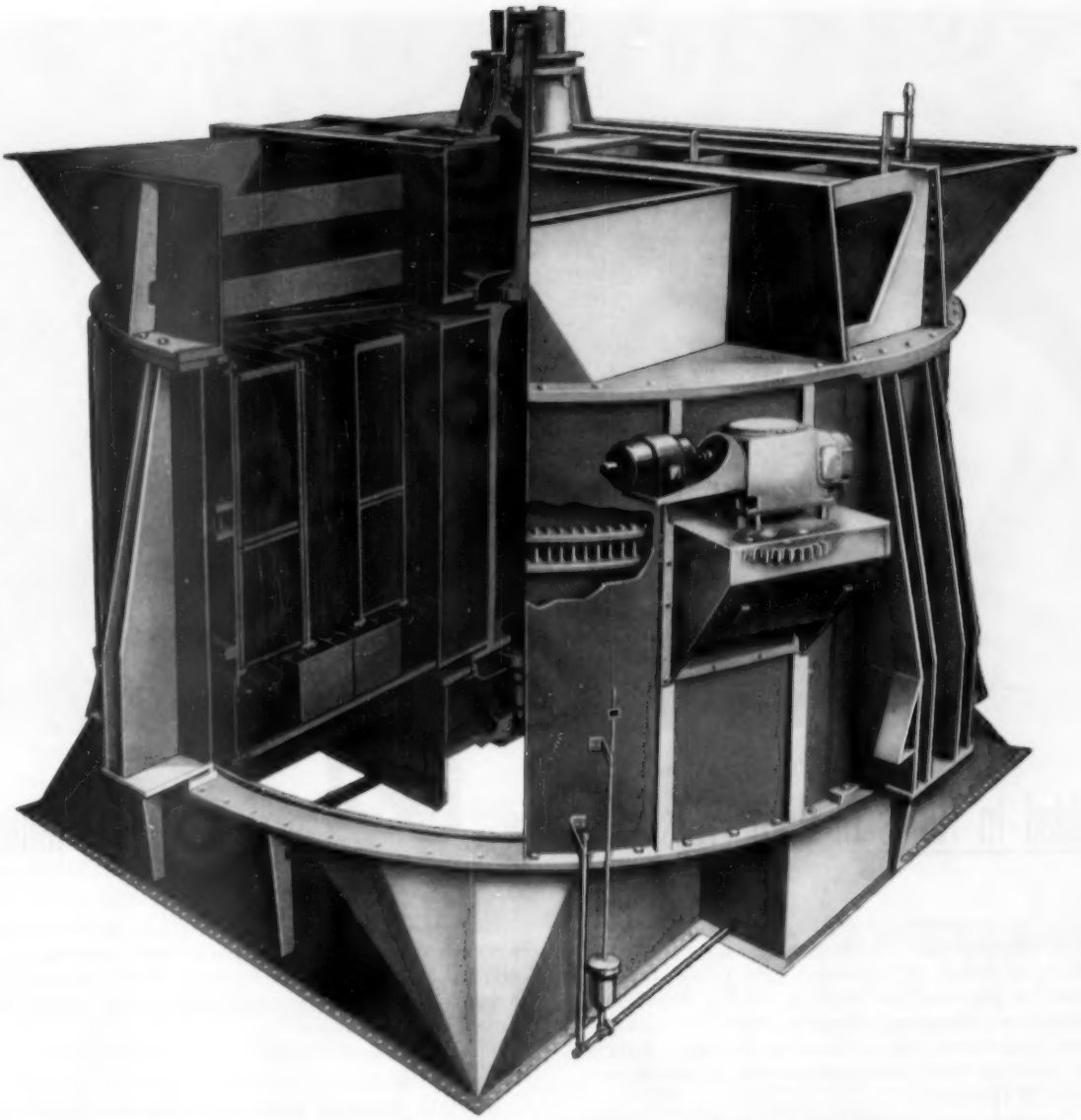

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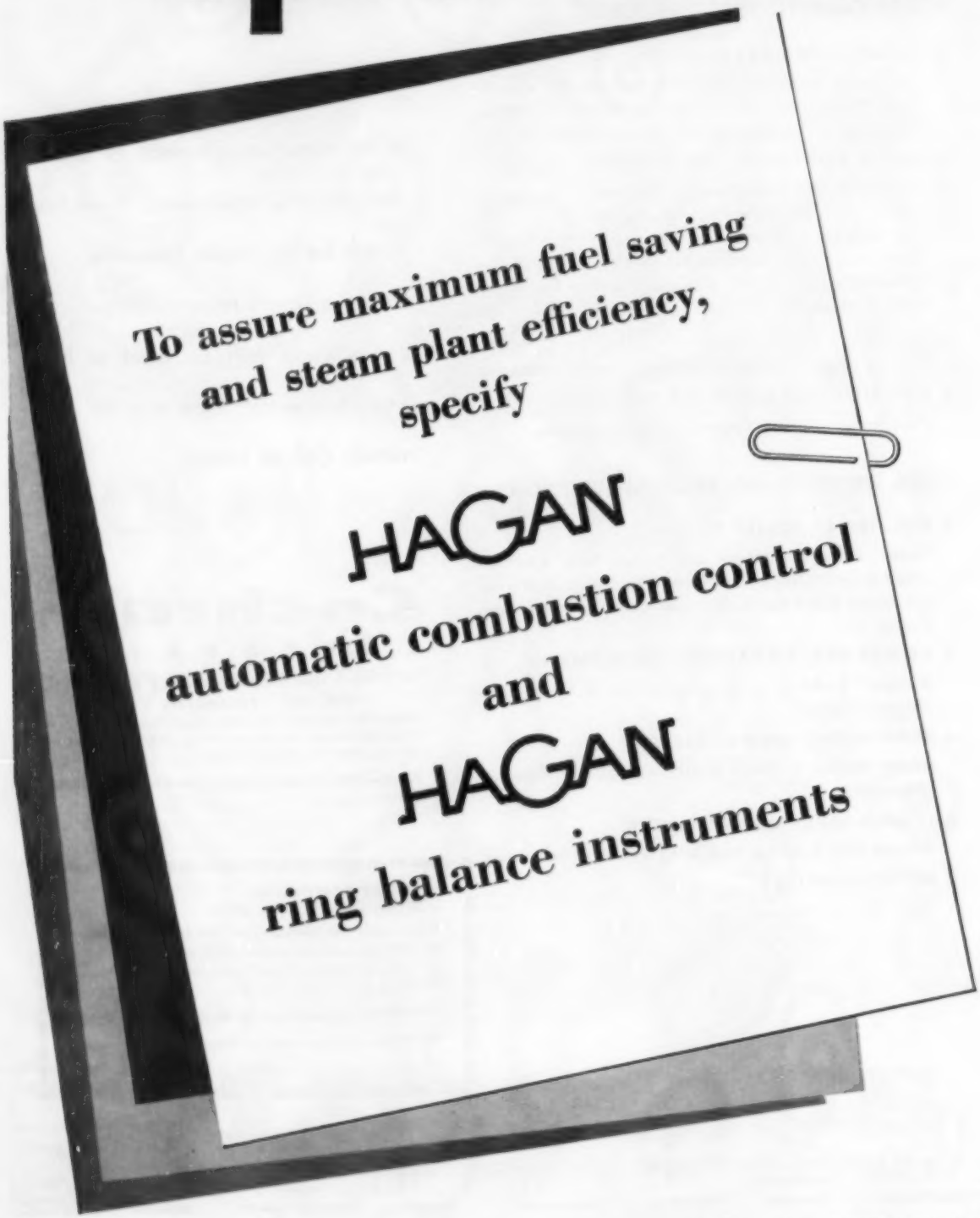

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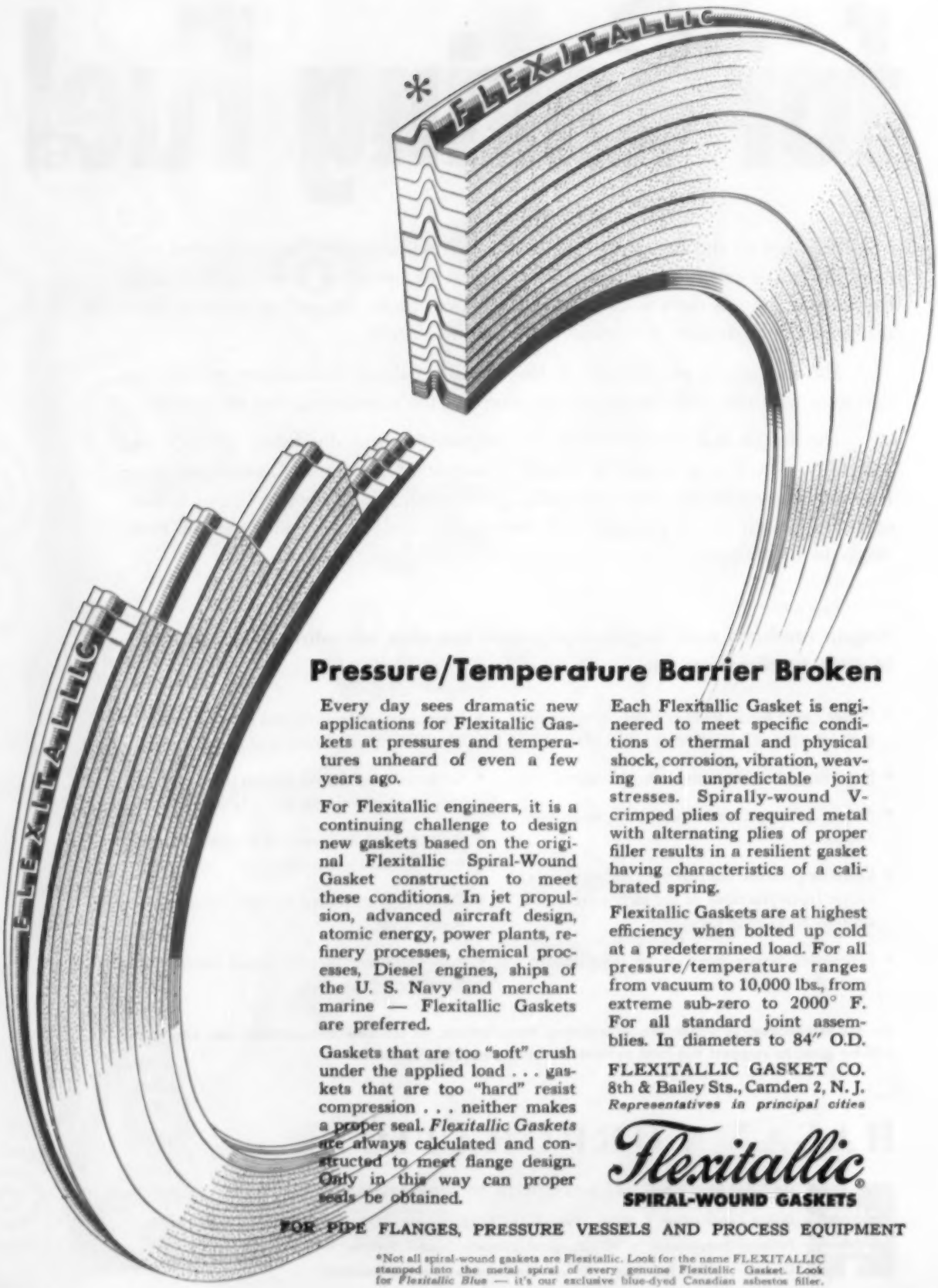

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Editorials

An Imaginative Solution to Fuel Shortages

One of our British contemporaries, *Power and Works Engineering*, in its December editorial, "Short-Term Fuel Prospects," recalled to our mind the project of transporting natural gas from oil fields by barges in refrigerated containers at atmospheric pressure. This project scheduled for introduction on the Mississippi River is intriguing in its possibilities. As our English cousins see it this project, if successful economically, could make available the natural gas released in the oil fields of the world to all the markets no matter where they be. And so it could.

Briefly the project as originally envisioned would entail liquefying natural gas, principa'ly methane, in the Gulf Coast area, loading it in insulated tanks set on barges and moving the cargo at atmospheric pressure up the Mississippi and Illinois Rivers to the Union stockyards at Chicago. There the gas would be vaporized and used for fuel purposes. Further the tremendous amounts of refrigerating energy released in this vaporization process would be employed in chilling and cold storage of meats. In addition to the value of the gas as a fuel the available refrigerating energy, according to expectations, would be worth the equivalent of five cents per Mcf.

The project's initial construction costs are held to be less than half that for major gas-transmission lines delivering the same volume of gas. Power for barge transportation, it is hoped, will be relatively inexpensive since the tow-boats could be operated largely off the small amount of natural gas evaporating from the storage tanks with some liquid kept in the tanks at Chicago for fuel for the return trip. Actually, though, operating costs must await the grim findings of experience. Therein lies the answer to whether a new form of fuel transportation is with us or not.

We shall follow developments as closely as possible as will, of course, the gas supply industry and the very rich market it serves. The existence of a liquefied gas barge system would truly make it possible to bring the natural gas supplies of oil fields all over the world to any market. Further, as new supplies came in or old fields became depleted there would be no problems of disposal of old or capitalization of new gas transmission lines. Certainly, this is a most appealing prospect.

Recognizing Young Engineers

Studies in psychology and sociology have provided ample evidence that two of the most fundamental human desires are the wish for security and the wish for recognition. Like other human needs, these wishes can be carried to extremes that are self-defeating, as was pointed out in an editorial entitled "The Myth of Security" which appeared in the February, 1950, issue of COMBUSTION. Evidently times are changing, for in contrast to this overemphasis upon security, now happily past, the young engineer has all too often been the unintentional recipient of insufficient recognition. Actually this has generally been caused by a combination of oversight on the part of management and the natural human tendency for executives to continue playing the team that has achieved success for their enterprise.

Yet one of the basic characteristics of the free enterprise system is its dynamic quality. Large industrial organizations may employ several hundred recent engineering graduates each year. These young engineers have been growing intellectually throughout their college days, and the more promising among them have also gained leadership experience in extracurricular activities. For their own professional development, this growth must be continued, possibly even accelerated. At the General Assembly of the Engineers Joint Council held in New York on January 21, E. L. Chandler, assistant secretary of the ASCE, referred to management and employee responsibility in engineering as follows:

"Young men of professional spirit want to be recognized and accepted as individual members of their profession. They want opportunity to prove their abilities. They need encouragement. . . . It is not at all intended to imply that management is under obligation to pamper employees. If opportunities for personal improvement are made available, it soon should become evident to management which employees have the ambition to make the most of them...."

The need for direct recognition increases following the completion of orientation and training programs. Young engineers may be content to engage in routine calculations and testing procedures for a time that probably varies with their background and temperament. But sooner or later, the most promising of them will evidence the sort of healthy discontent that can be satisfied only through some sort of recognition of their efforts by management.

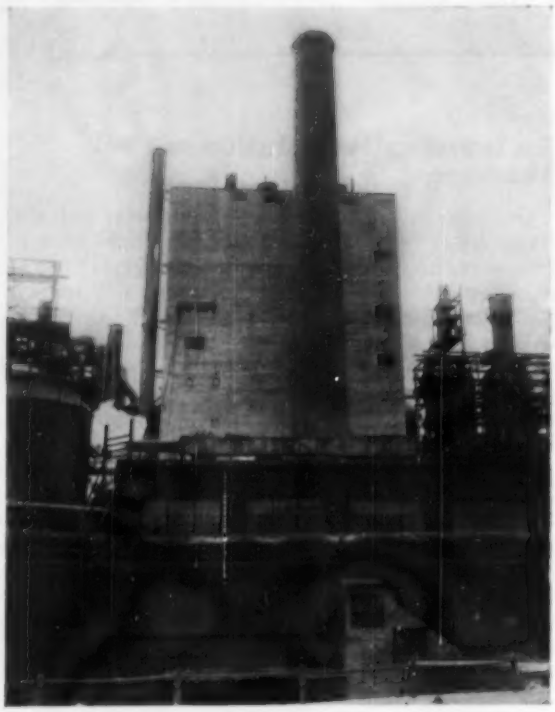
One organization that is doing an outstanding job in this direction is the Steam Division of Westinghouse Electric Corporation at South Philadelphia. This was evidenced at a conference for technical editors held last month to mark completion of a new development laboratory for steam and gas turbines. Even more impressive than the extremely well equipped facility were the quality and the morale of the young engineers. The vast majority of them ranged under 35, and they not only conducted the inquisitive editors through the laboratory but also delivered a series of outstanding technical papers. A strong impression lingered that management valued its engineering staff and was making a genuine effort to accord young engineers deserved recognition. This is a practice that commends itself to widespread emulation.

Weirton Steel Company Installs Its Fifth High-Pressure Steam Generator

By CHARLES H. LEATHAM, JR.

Project Manager, The Rust Engineering Co.

This article describes the installation of a 400,000 lb-per-hr tangentially fired steam generating unit designed to burn pulverized coal, coke-oven gas and blast-furnace gas. One of the most interesting problems was the erection of this unit in a relatively confined area, as shown by the accompanying illustrations.



View of east wall emphasizes the great height of the new structure

WHEN the Weirton Steel Company of Weirton, W. Va., division of National Steel Corporation, planned the installation of their No. 4 Blast Furnace, they anticipated that its operation would result in an oversupply of blast furnace gas and an increased demand for high-pressure steam. It was estimated that sufficient blast furnace gas in excess of existing burning capacity would be available to produce 325,000 lb of steam per hour at 850 psig, all of which could be profitably used to supply new steam demands or to reduce the use of coal in the production of steam.

In order to add the necessary capacity and fuel burning flexibility to their steam generating facilities, a contract was awarded to The Rust Engineering Company of Pittsburgh, Pa., for the design and construction of an addition to an existing boiler plant to include to a Combustion Engineering steam generating unit having a peak capacity of 400,000 lb per hr (when burning pulversized coal) and a capacity of 325,000 lb per hr when supplied only by blast furnace gas. This unit was designed to burn blast furnace gas, pulverized coal, or coke-oven gas in any desired proportion. However, in furtherance of Weirton Steel's plant-wide program for the prevention of air pollution, it is intended to make exclusive use of coke-oven and blast-furnace gases in the new installation.

After considerable study of several possible sites it was decided to locate the new unit on the site of an unused part of the existing boiler plant between two existing low-pressure boilers. This site had the advantages of permitting operation by present boiler room crews, being close to the turbine-generator building, and being adjacent to existing water, steam and gas lines. Obvious disadvantages were its small size and poor access for construction. At grade level the site measured only 57 ft wide and 64 ft long. At a distance of 40 ft above grade the site was further restricted to a width of only 50 ft by gas ducts which could not be moved; but at this height, and above, it was possible to increase the length of the new structure by building above the old boilers.

In order to stay within the above site limitations and yet provide adequate space, support and access for the steam generating unit it was found necessary to locate the deaerating heater and pumps in the space available above the old boilers at the south of the new unit, and to install the air preheater and fans above the new unit. This design resulted in a building measuring 57 ft by 64 ft at grade level and 50 ft by 80 ft from 40 ft above grade to the top, which is 166 ft above grade.

Removal of the existing section of brick and steel boiler plant building and excavation for the new building were complicated by the necessity of not interrupting operations of adjacent steam generators or blocking, for any

appreciable period, the tracks which served the nearby Blast Furnace No. 3.

Adequate support for the new structure was obtained by pouring a concrete slab 4 ft thick over the entire ground floor area. 586 tons of structural steel and bunker plate were hoisted into place in the structure by a guyed derrick which was progressively moved to the top of the structure. The larger equipment items, boiler parts, 80 tons of platform and stair steel, and 95 tons of reinforcing steel were also lifted by this derrick.

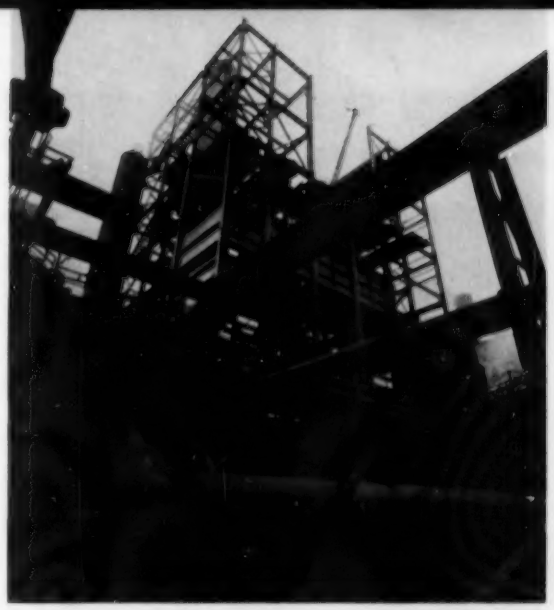
The north, east and west walls of the new structure are constructed of buff brick, while the south wall is constructed of corrugated galvanized iron to permit removal if future high-pressure boilers are constructed between the new plant and the four older high-pressure boilers.

Ventilation of the building was an important consideration because of the proximity of Blast Furnace No. 3. Fixed concrete louvers are installed in the brick walls of the building at various points. These louvers measure about 4 ft by 6 ft each and are equipped with aluminum sliding shutters. The dust tight coal conveyor room is provided with 30-in. exhaust fan receiving its air from louvers in the coal conveyor gallery. The dust tight electrical control room has louvers with filters in the wall. Two fans in an interior wall of this room exhaust into the main building enclosure. Operation of the forced-draft fan will create an updraft of air through the building, thus cooling the operating floor and removing the air exhausted from the electrical control room. Two 48-in. gravity ventilators in the roof are provided to permit the escape of hot air accumulating under the roof.

New Steam Generator

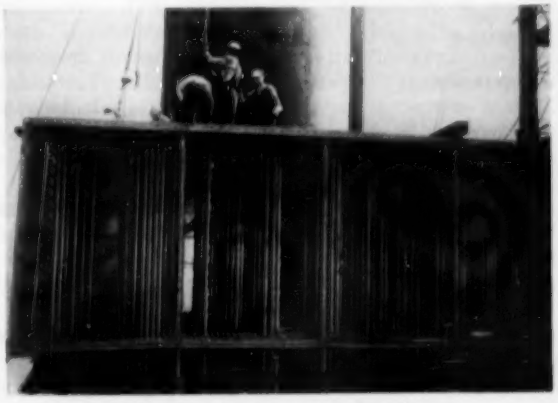
The new steam generator is a three-drum, single-pass unit manufactured by Combustion Engineering, Inc. The furnace measures 20 ft by 22 ft and is completely water cooled by 297 closely spaced 3-in. OD tubes having a total heating surface of 17,700 sq ft. Furnace volume is 29,500 cu ft. At each corner of the furnace there are two burners each for pulverized coal, coke oven gas, and blast furnace gas. Burners are aimed tangent to a small circle at the center of the furnace so that the motion of incoming air and fuel causes a rapid swirling action within the furnace, thus increasing the effective length of flame travel, improving the mixing of air and fuel, and lengthening the time and velocity of contact between the hot gases and the furnace water walls. This type of firing is commonly called "tangential firing" and has been pioneered and developed to an exact science by Combustion Engineering, Inc. The pulverized coal burners and accompanying air nozzles are automatically tilted up or down by Leeds and Northrup equipment in order to maintain a constant steam temperature at the superheater outlet. Coke oven gas pilots are provided for ignition and are equipped with thermocouples which actuate indicator lights at the panel board to show which pilot lights are burning. Pilot lights are lighted manually.

The mud drum of the boiler is located 80 ft above ground level and the two upper drums are about 23 ft higher. Upper drums are 60 in. in diameter and the mud drum is 54 in. All pressure parts are designed for an operating pressure of 925 psig. The slag screen consists of 111 tubes of 3-in. outside diameter on 7-in. centers and the main boiler bank contains 1875 tubes of $2^1/_2$-in.



View of steelwork during erection indicates limited space available for construction

Main bank of boiler tubes during installation; superheater header is in place above and in front of top drum; water wall tubes are not yet in place



Inserting the air preheater tubes

View of north and west walls showing extension of trolley rail for twelve-ton hoist at induced-draft fan floor

diameter on an average center to center spacing of 3½ in. Total heating surface of the boiler is 30,360 sq ft.

The superheater is an Elesco welded-joint type and is located between the slag screen and the first row of main boiler tubes. In addition to the safety valves required by ASME code, the superheater outlet is also equipped with an air-actuated power control valve as manufactured by Manning, Maxwell & Moore, Inc. The outlet of this valve is equipped with a baffle-type silencer.

The air preheater is located above the boiler and consists of 3060 vertical 2½-in. tubes through which the flue gases pass upward on the way to the induced draft fan. Air from the forced-draft fan makes two passes around the tubes and then is conducted down each side of the steam generator to the burner windboxes at the operating floor. Because air temperatures are expected to be as high as 700 F, 9050 sq ft of high temperature block were required for insulating these ducts.

Auxiliary Equipment

The forced-draft fan is located on a heavily reinforced concrete floor 116 ft above ground level. The fan is a Buffalo Forge Company double-width, double-inlet unit with outlet damper control and single angular upward discharge. The fan will deliver 141,000 cfm of 100 F air against a static pressure of 13.6 in. when driven at 1180 rpm, and requires 430 bhp. Fan blades have a backward curve rendering the unit non-overloading. The fan is driven by a General Electric 500-hp induction motor.

The induced-draft fan which is located on the floor above the forced-draft fan is a Westinghouse-Sturtevant No. 1014 TVID unit and is one of the largest fans ever built for this service by that organization. Capacity of the fan is 463,000 cfm against a static pressure of 14.6 in. and at 525 F. A 1500-hp induction motor rotates the fan at a constant speed of 600 rpm. Inlet dampers are provided. Space arrangement required that the fan be mounted with its center line 8 ft, 6 in. above the floor. Removal of the rotor, which weighs about 11 tons, will be a complicated procedure. A trolley mounted chain fall will be connected to each end of the shaft to move the rotor to a small car running on tracks in front of the fan. This car will then be moved the length of the building until it rests under the 12-ton electric hoist which is moved by electric trolley on a monorail extending about 20 ft outside the building. The electric hoist will then lower the rotor about 150 ft in eight minutes to a truck or rail car at ground level. A spare rotor is stored at the induced draft fan level under the rear end of the same hoist trolley rail. The electric hoist and trolley were manufactured by Shepard-Niles. Doors or bricked-up openings are provided at each of the principal floors of the building to permit use of this hoist for replacement of other equipment.

The steam generator is equipped with eight Diamond Power Specialty Corp. long-retractable sootblowers and fourteen short retractable units with wall boxes provided for an additional eight long-retractable units if future conditions should require their installation. 650-psig steam, obtained by use of a reducing valve, is used as the blowing agent, and compressed air supplies the power to move the blowers and operate their individual steam valves. A panelboard at the front of the boiler on the operating floor controls the automatic sequential operation of the sootblowers.

Coal is conveyed to the new building by a Chain Belt Company 24-in. belt conveyor measuring 177 ft from center to center of end pulleys. This conveyor receives coal from the end of the coal conveyor serving the four older high-pressure boilers. Electrical interlocking is provided between the old and new conveyors to prevent coal being dumped on the new conveyor when it is not running. A self-propelled tripper distributes coal as desired along the 50 ft length of the new bunker, which has a storage capacity of 350 tons. 3400 sq ft of steel plate were employed in construction of the bunker. Coal drops by gravity through vertical cylindrical chutes to the pulverizer feeders and is measured by Bailey coal meters while enroute.

The coal conveyor is supported between the old and new buildings on a structural steel bridge measuring about 90 ft long. This bridge is enclosed on the sides and roof with galvanized corrugated iron. Floors at front and rear of the conveyor itself are made of precast concrete slabs, and the area under the conveyor is enclosed by removable sheet steel plates. Adjustable aluminum ventilating louvers are provided in the walls of the gallery.

Two C-E Raymond bowl mills are located on the ground floor and receive their coal from the feeders located on the operating floor. Each feeder is driven by a 2 hp variable speed d-c motor. Each pulverizer has a capacity of 23,800 lb of coal per hour ground from three-fourth inch lump to 70 per cent passing through a 200 mesh screen. Maximum demand for coal at peak (400,000 lb per hr) output of the boiler is estimated to be 43,300 lb per hr. Each pulverizer serves one burner at each of the four corners of the furnace and is driven by a 250-hp induction motor.

Fuel Supply

Blast furnace gas is brought to the new unit by two 48-in. lines which branch from an existing duct terminating about 50 ft north of the new building. One of these new lines serves the burners at the northeast and northwest corners of the furnace and the other line continues along the west side of the building and serves the burners at the southeast and southwest corners. A 48-in. butterfly valve is provided in each of the new lines and automatically controlled to provide equal gas pressure and flow at the four sets of burners and to restrict the flow of gas if main line pressure drops.

Treated water for operation of the boiler is obtained from an existing water treatment plant located at the rear of the older high pressure boilers. Two booster pumps at ground level of the new building pump this water to the deaerating heater which is located approximately 70 ft higher. These pumps are Dayton-Dowd Peerless units with a capacity of 1500 gpm each against a discharge head of 150 ft. One pump is driven by a 75-hp General Electric induction motor and the other by a Terry steam turbine.

The deaerating heater was manufactured by Elliott Company and is a tray type unit with horizontal storage tank. The unit is of the "thoroughfare"design in which low-pressure steam flows through the heater enroute to other uses. Inlet and outlet 18-in. connections of the heater are made on the upstream and downstream sides, respectively, of a butterfly valve installed in the 24-in. main exhaust steam header. Opening of the butterfly valve is controlled automatically in response to variations of feedwater temperature. The deaerating heater has a capacity of 600,000 lb per hr of zero oxygen feedwater and the storage tank has a 2000 cu ft capacity, or about 12 min at maximum output.

Two boiler feedwater pumps are located on the floor below the deaerating heater. These pumps were manufactured by the Ingersoll-Rand Company and each has a capacity of 800 gpm against a discharge pressure of 1050 psig. Each pump is direct-connected to a General Electric 700-hp, 3550 rpm induction motor. Piping to and from the pumps permits either pump to serve the new boiler or the older high-pressure boilers and permits either pump to receive its water through a separate bypass around the deaerating heater, if required.

A Hagan three-element system of feedwater control is employed. Two 4-in. air operated valves are controlled in parallel by a single set of feedwater flow, steam flow, and drum level measuring and transmitting devices. The system incorporates a blowdown compensator unit.

On the same floor as the boiler feedwater pumps, and near them, there are two Dayton-Dowd service water pumps each having a capacity of 1000 gpm against a head of 220 ft. These pumps are driven by 75-hp, 1750-rpm induction motors, and supply water for bearing cooling and other purposes throughout the new boiler plant.

Ash handling facilities were manufactured by the Hydro-Ash Corporation and consist principally of an extension to the existing hydraulic sluicing system. Bottom ash is collected in a brick-lined steel ash hopper with normally dry bottom although the construction of the hopper will permit flooded operation. Sluicing nozzles are provided for removal of this ash through a hydraulically operated door. Dust and fly ash from the rear passes of the boiler are conducted by dry vacuum to a water jet exhauster which discharges them to the sluice extension. The new sluiceway is located out of line with the older system and is at a higher elevation so that interconnecting them required the use of a sloped section with nozzles to provide right-angled turns at either end. The ventilating system of the ash tunnel was changed to permit connection of the new sluice at the end of the old sluice and to provide access to the personnel elevator at the ground floor.

Coal conveyor gallery between old building at the right and new building on the left

Design of Piping System

The piping system of the new station was designed for the greatest possible adaptability to present and future plant needs. The new boiler can deliver its steam either to the header in the turbine-generator room or through a pressure reducing valve to the main 225-psig steam system. Motor operated valves are employed to isolate the reducing valve, to shut off the main lead from the new boiler, or to operate the reducing valve with steam received from other boilers. The pressure reducing and desuperheating station has a capacity of 400,000 lb of steam per hour reduced from 825 to 225 psig. The main reducing valve is a Fisher, type 7-6, 6 in. by 6 in., with piston operator and has a capacity of 250,000 lb per hr. The additional capacity required is obtained by manually controlling the flow through a 6-in. globe valve arranged as a bypass for the main valve. Hagan instruments control the operation of the reducing valve as well as the flow of water to the Hagan steam-water nozzles located in the low pressure line. This reducing-desuperheating station is located on the same floor as the boiler feedwater pumps, and its instruments and controls are installed on a panel board along with similar instruments for the boiler feedwater pumps.

Electrical service to the new station is received at 6900 v, 3 phase, 60 cycles. The electrical control room is a dust tight structure located above the coal bunker and beneath the forced draft fan floor. Main cubicle type breakers control power from the incoming feeder and out to the older high-pressure boilers, Blast Furnace No. 3 and the local station service. Starters for the larger mo-

tors are housed in cubicles adjacent to the main breakers. A power transformer is also located in this room and it supplies 480-v, 3-phase service for the smaller motors. A 480-v switchgear including a main 3000-amp breaker and six 1600-amp branch breakers is provided adjacent to the power transformer. The 480-v motors are controlled by starters conveniently located throughout the plant. The complete electrical installation was made by Allegheny Industrial Electrical Company, Inc.

The 6900-v motors driving the forced draft fan, the induced draft fan and the two boiler feedwater pumps are of drip-proof construction with type B insulation. Other pump motors and the motors driving the pulverizer and air compressor are all totally enclosed, fan-cooled units.

Instrumentation and Combustion Control

Instrumentation in the new plant is principally of Bailey Meter Company manufacture. Combustion control is basically a Hagan Corporation system. Panelboards were designed and factory assembled by Hagan Corporation. Instruments and controls are centralized on the main control panel measuring about 23 ft long and installed opposite the front of the new steam generator. Steel plate enclosure is provided above the panel to the under side of the roof over the "lean-to" section of the building, and at each end of the panel to the rear wall of the lean-to. This provides a dust-tight room at the rear of the panelboard measuring 7 ft by 23 ft by 10 ft high. A battery of control relays, sedimentation traps and other devices not mounted on the rear of the board but related to its operations are mounted on the rear wall of this enclosed room. Piping and wiring installed on the board at the factory terminates in connection blocks or terminals at the top of the panel board. Except where pressure or temperature required the use of steel pipe, instrument and control piping throughout the plant consists of Bailey multiconductor copper tubing in steel armored housing.

In general the control scheme is intended to burn all available blast furnace gas and coke oven gas in the furnace and use coal only to supply the necessary steam when gas supplies are inadequate. Gas valves close whenever pressure in gas mains falls or whenever boiler pressure exceeds the set limit even after all coal flow has been stopped. The master sender provided for the new unit is mounted on the panelboard in the older boiler house and acts as a spare for the original master sender. Manual controls on the old board permit shifting load either to or from any of the five high-pressure boilers.

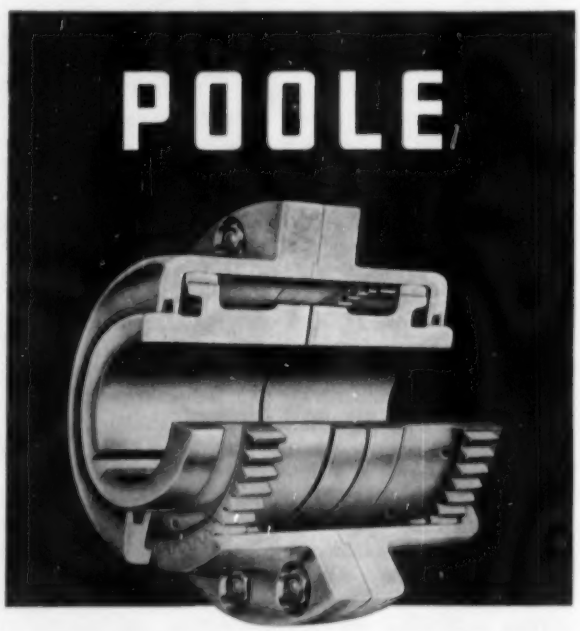
A Bailey smoke density recorder is provided. Gas sampling is arranged by use of a bypass pipe around the induced-draft fan.

Air for the operation of the control system is provided by a Fuller two-stage, water-jacketed rotary compressor capable of delivering 122 cu ft of free air per minute against a discharge pressure of 100 psig. This unit is driven at 1750 rpm by a 30-hp totally enclosed, fan-cooled motor. Auxiliaries include a 30-in. diam by 7-ft high vertical air receiver, a 27 sq ft horizontal Ross water-tube aftercooler, and a Hankinson condensifilter. A connection to air lines in the old boiler house is provided between the receiver and the condensifilter, so that unfiltered air may be supplied to or received from the existing air supply system as required.

The height of the new building made it imperative that an elevator be provided for operating personnel and for repair parts. The location of a shaft for this elevator was one of the most difficult problems of design, but a shaft approximately eight feet square was finally accommodated in the southeast corner of the gound floor area. The Otis Elevator Company installed an elevator of 4000 lb capacity with a travel speed of 100 ft per min. Machinery for this elevator was installed in a brick enclosure at the top of the shaft directly under the main roof of the building.

As design of the building progressed it was found possible to provide a machinery hatchway, approximately eight feet by ten feet for the height of the building and adjacent to the boiler feedwater pumps. Monorails were provided above the pulverizers to a doorway near the ceiling and measuring 9 ft wide by 14 ft high for removal of equipment from the ground floor to the rail tracks west of the building. It is also possible for the 12-ton electric hoist, provided for induced-draft fan service, to receive loads at several floors reachable by the machinery hatchways and deliver them to the tracks.

It is anticipated that the new steam generator with its relatively high operating efficiency, 79.5 per cent on blast furnace gas alone, 86.3 per cent on coal alone, will effect considerable fuel economy for the Weirton Steel Company. The peak capacity of 400,000 lb of steam per hour added to present facilities without removal of any old equipment and without the selection of a site isolated from present operations will also provide the maximum economy of operating labor and other cost factors.



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Control of Engineering Costs*

By K. W. REECE, Vice President, Ebasco Services, Inc.

The ways and means by which control can be established over engineering costs are of considerable interest to engineering management. This paper outlines certain methods to achieve this goal of a higher quality finished project for a low cost.

ENGINEERING accounts for an important segment of the expense of building facilities to meet the needs of people everywhere. The magnitude of engineering cost depends upon the size of the project, its geographical location and its complexity. The total expense may be as low as 2 per cent on a very large project and as high as 15 or 16 per cent of the total cost on smaller projects with many intricate problems present.

The engineering cost usually falls into three general categories:

(1) Preliminary investigations and planning.
(2) Design and general engineering.
(3) Field engineering during construction.

As a rule more than three-quarters of the total engineering cost is in the design and general engineering in connection therewith. This paper deals separately with each of these categories, with the design and general engineering as the main subject. The figures used and the methods suggested are drawn from the experience of the company with which the writer is associated.

Good engineering and design is the very heart of a successful project. In general, money spent on first-class engineering is well worthwhile as it makes for an overall lower cost of the project and fosters long life, suitability for the purpose for which it is designed, low operating costs, a high degree of reliability and the other characteristics of superior service.

Therefore control of engineering costs should not be directed solely towards cutting down with a view to getting a very low dollar expense for this work. The quality of the work, and its effect on the project, should be the prime consideration. However, within these limitations there is a wide field for money savings for the benefit of the client in envisioning the project, and putting that vision down on paper, ready for the construction forces.

Preliminary Investigations

A project generally starts as an idea. This idea must be developed, promoted and financed before actual construction starts. The amount of work involved in doing this may be considerable, and includes a wide range of talents. It generally comprises a substantial amount of first-class engineering services by people especially skilled and suited for the type of work that is required in determining the feasibility, scope and general features of the project.

The amount of money spent on this engineering phase of the project is controlled by the competence and experience of the people employed upon it, the requirements of governmental bodies and the need for information to solve the many business, legal, location and technical problems involved. Management can do little to control such costs except to see that adequately qualified people are assigned to the job, to make sure that the objectives are kept clearly in view and no lost motion is allowed to develop.

In some cases the client does its own preliminary work, and then the project is turned over to the professional engineering organization to design. In other cases the preliminary work is done by the same organization that designs the project.

There are instances, of course, where little or no preliminary work has been done, and where it must be carried out concurrently with design. This situation tends to increase the cost of the engineering work, but does not alter the principles of control set forth in this paper.

For purposes of simplification, this paper assumes that the location and general features of the project have been determined from the preliminary investigation by the time it has been turned over to the professional engineering organization for design and general supervision of construction.

Field Engineering

Field engineering during construction usually is an integral part of job supervision, and its cost is controlled by the same methods and supervision as is the total construction cost.

There are situations, however, where part or all of the design is done in the field as part of the field engineering. Where the construction work is let to a contractor on a unit price basis, the owner may maintain an engineering organization to inspect the work, and make sure that the contract is being carried out as specified.

This paper assumes that the job is designed and generally directed by a professional engineering organization, that the field is furnished complete construction drawings as needed, and that no separate field engineering organization is required.

General Engineering and Design

Fig. 1 shows the division of design and general engineering cost between the engineering component and the drafting component for five typical jobs. These proportions will vary between organizations depending on the division and classification of work. The dividing line between engineering and drafting is in many cases quite flexible and indeterminate. Also, department titles vary widely and in some instances a considerable amount of engineering work may be performed in the so-called drafting department and costs consequently re-

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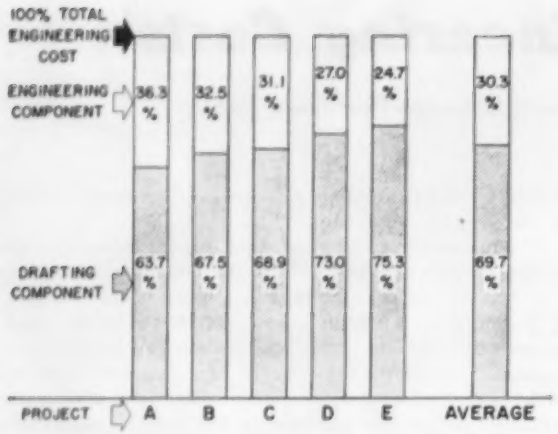


Fig. 1—The division between the design and engineering cost between the engineering component and the drafting component for five typical jobs shows above

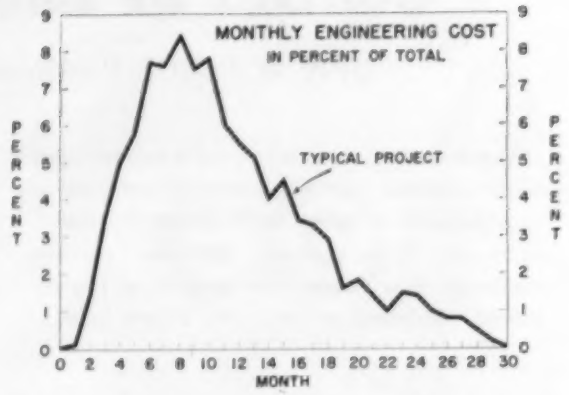


Fig. 2—Typical distribution of engineering costs of a project initiated before design work had been completed and carrying along for thirty months to its finish

corded as drafting. In other instances, the reverse may be true with a resulting lower percentage of total cost attributed to drafting. The important point is that by far the larger part of this portion of the engineering, regardless of terminology, is especially susceptible to sound cost control methods with resulting savings of substantial extent.

In a more leisurely period in engineering history the entire design of a project was completed prior to the start of construction work. This is still done to some degree when lump sum or unit price contracts are let for entire jobs. More and more, however, substantial savings in interest and other costs are realized by clients through starting actual construction very shortly after authorization and before the design work has progressed very far. Fig. 2 shows the typical distribution of the engineering cost of such a project with a thirty-month period from start to completion.

Today most projects are complex, and call for a wide variety of engineering talent. Any such schedule as the one shown by Fig. 2 requires a concentration of men, and careful organization to avoid high engineering cost, delays and bottlenecks which can and generally do, run up the construction cost.

Essential Factors

In organizing engineering work for the most efficient production at the lowest possible cost consistent with the highest quality, some essential factors must be recognized.

(1) The engineering and design work is not an end in itself but must be integrated with the construction of the project.

(2) A construction schedule is essential prior to scheduling the design work.

(3) Purchasing should be scheduled to insure the receipt of manufacturer's drawings in ample time.

(4) Decisions should be made early enough to allow the design work to go forward in an orderly manner. Changes are costly and should be held to a minimum. However, sometimes they are unavoidable or may be desirable. Changes should be made only after proper consideration has been given to technical and economic factors. It is usually wise to explain to the client the reasons for the change and that it will mean an increase in engineering cost.

(5) Due dates for drawings should be established on a realistic basis. This cannot be emphasized too strongly. Once established every effort should be made to meet the schedule.

(6) The engineering and design-drafting personnel should be competent and also should be willing and able to produce rapidly and accurately.

These factors are essential to realize the lowest possible engineering costs, but of course they are even more important in assuring a high quality project built on time and with a minimum of confusion and friction.

Organization

Good organization is prerequisite to control of engineering cost, in order to:

Fix responsibility
Make decisions
Insure prompt transmission of information
Coordinate the effort
Avoid duplication

It is easier to secure the desired results if the preliminary work, design and general engineering and field engineering are done by the same organization. The personnel involved have had experience in working together. The preliminary work is generally carried out so that it can be picked up by the design and project engineers without lost motion. The designers know from experience the needs of the construction forces, and the field in turn knows just what to expect from the design office. These factors all make for lower engineering costs.

A type of organization for the design and general engineering work which has proven to be effective is as follows:

(1) A group of department heads, consultants and their staffs skilled in the various fields of engineering involved, is available for consultation, advice and direction.

(2) If the job is large enough, a coordinator is as-

signed to the job. His duty is to see that the job goes smoothly and that dates are met on schedule, not only in the case of drawings but more importantly that decisions are made, equipment specified and purchased, and all other items are handled promptly in order that the required construction drawings can be processed in a sequence that meets construction requirements.

(3) A project engineer is assigned to each job from the engineering division whose services predominate or are controlling. Thus, for a steam electric generating station the project engineer would be a mechanical engineer whereas for a hydroelectric generating development the project engineer would by a hydraulic engineer. General responsibility for a project is the project engineer's. A good project engineer must not only be technically qualified but must be qualified as an administrator and diplomat as well.

(4) The design department is headed by a superintendent. It is set up in five divisions, namely, Architectural-Structural, Concrete-Hydraulic, Electrical, Mechanical, and Industrial, each with a chief. The staff in each division is divided into squads, of proper size to suit job requirements, and each is supervised by a squad leader. The squads turn out the design drawings.

This organization has many other duties than the ones outlined in this paper, but those named above directly bear on the control of the cost of the engineering work.

Tools for Control of Cost

Written schedules, estimates, progress reports and records are necessary tools in controlling costs. The scope of the average job is so great, it moves ahead so swiftly and the number of people engaged on it is so large, that proper supervision of cost by inspection, intuition and impression is impossible.

The following ten forms, developed from long experience, are typical of those that are being used successfully.

(1) A man-day estimate with list of drawings needed for the job, to serve as a basis for the engineering estimate and as an overall control.

(2) A cost estimate based on the man-day estimate, and priced out from experience records, including overheads and proper allowance for contingencies.

The estimate, once established on a sound basis, serves as a budget for all phases of the engineering work applicable to the specific project. An estimate is, of course, only a target and must be used as such. In order to determine performance and progress, records are kept, such as:

(3) An engineering progress report, showing man-days expended on each drawing and cost to date, and per cent of budget expended.

(4) A drawing schedule, with spaces for all pertinent information such as due dates, per cent of design completed and engineering approval dates. Progress is recorded from start to completion.

(5) A job status report showing the detailed manpower situation and used to control assigned manpower.

(6) A time report used by each individual for recording daily the time worked by jobs to the closest one-quarter hour.

(7) Overtime report prepared by the individual when overtime is required and specifically authorized.

(8) A work report, on which each man records, daily, to the nearest one-quarter hour the time worked by him drawing numbers.

(9) A record of drafting time for each drawing, compiled from the daily work reports.

(10) An-engineering-to-design-information-sheet, a fill-in type, covering the usual primary data required prior to start of design, facilitates the transmission of necessary information from engineers to designers and draftsmen. It provides a check list of information and its proper use will prevent the overlooking of vital information required by the design department.

The list of information shown above is basic. It is subject to adjustment, both in respect to omissions and additions, to fit special situations.

Getting Results

The best organization and the finest set of forms will fail of their purposes unless they are efficiently used. Teamwork is essential.

Engineering cost is largely made up of the time spent by professional and technical people who contribute ideas, services and specialized work according to their abilities toward the construction of a useful project. By training and experience this class of people is accustomed to working together. By nature they are intelligent. By temperament they are individualists and opinionated. Best results are obtained from such people by leading them, and not by driving them. One of the most effective means of controlling engineering costs is to create and foster in each individual assigned to a project the feeling that he is playing an important part, no matter how small his contribution, in the successful completion of the venture.

The machinery will not work well without good management. The records for the purpose of controlling cost must be well kept, and be available promptly for the use of supervisors. Nothing is more useless than statistics that arrive after the need for them has passed. The various forms and reports are designed to show where overruns appear to be developing and the location of road blocks. Management should move promptly to correct such situations before they become serious. Generally simple remedies will work; sometimes more drastic steps are necessary. Most projects move so swiftly that delays and undue deliberation will mean costs higher than they should be.

No formula can be laid down that will insure good management. Some of the economies growing out of good management can, however, be listed.

Drawings can be simplified greatly, with substantial savings in cost, and without loss of clarity. Minimum cross hatching and shading, greater use of adhesive overlays or "appliques," showing only half of symmetrical objects and more extensive use of freehand sketching are some of the ways to effect these savings. Fig. 3 shows a typical exterior building elevation. The masonry work is shown in detail and the entire elevation is completely shown including repetitive items. Fig. 4 is the same elevation leaving out non-essential detail.

Fig. 5 is an example of the method of showing a turbine pedestal cross section before simplification. Fig. 6 is a simplified drawing of the same pedestal using symmetry to the maximum extent. Every unnecessary line, dimension or symbol costs extra money. In the aggregate their omission means substantial savings.

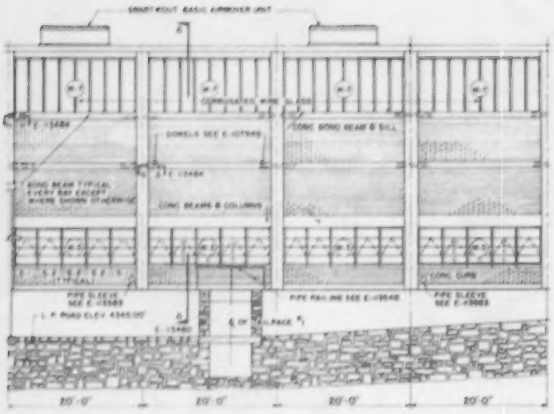


Fig. 3—Exterior building elevations pictured as above are costly with masonry work shown in detail and repeated

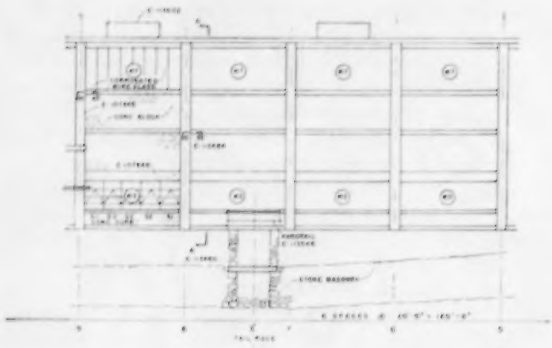


Fig. 4—Simplified drawing technique employed on elevation, Fig. 3, results in much lower drafting costs

Composite drawings in certain instances save drafting cost and reduce the number of drawings.

All applicable standards should be followed.

The work can be planned to reduce overtime to a minimum.

The time required for breaks in work periods can be greatly reduced by delivering refreshments to the work areas and with no loss in the benefits of such breaks.

Time consumed in locating required drafting equipment can be substantially reduced by seeing that all drafting personnel are adequately equipped.

Conclusions

The lowest possible cost of engineering consistent with highest quality can be realized by such means as:

(1) Establishing a cost atmosphere in the organization and developing cost consciousness in all personnel.

(2) Organizing with cost control as one of the major objectives.

(3) Defining the major scope of the work early in the development of a project.

(4) Releasing for production to design-drafting division only after major scope of work has been established and required detail information is available.

(5) Being alert for more economical methods of doing the job.

(6) Providing adequate standard forms and methods for recording charges and reporting progress as related to estimate and budget.

(7) Making maximum use of established standards and simplification procedures, particularly in the design drafting area.

(8) Setting up an engineering budget.

(9) Providing periodical review of progress and cost, checking the results against the budget and correcting the unfavorable situations disclosed by the check.

(10) Closing out the work as early as possible.

(11) Never being satisfied with results from the cost standpoint. An economically produced job could always have been produced more economically.

The client is the principal beneficiary of the control of engineering costs. The savings to be obtained are substantial, and should receive the close attention of the professional engineer charged with the responsibility.

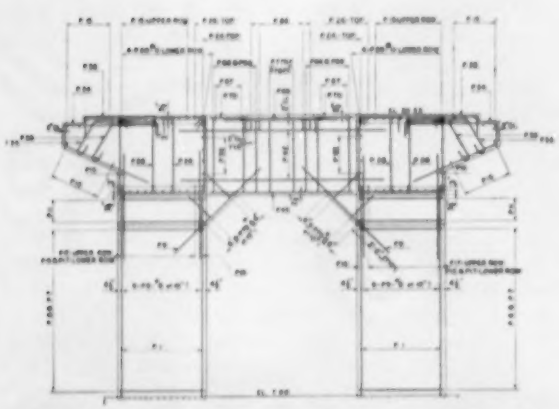


Fig. 5—Older drafting procedure applied to a turbine pedestal cross-section produces a number of unnecessary lines, dimensions and symbols

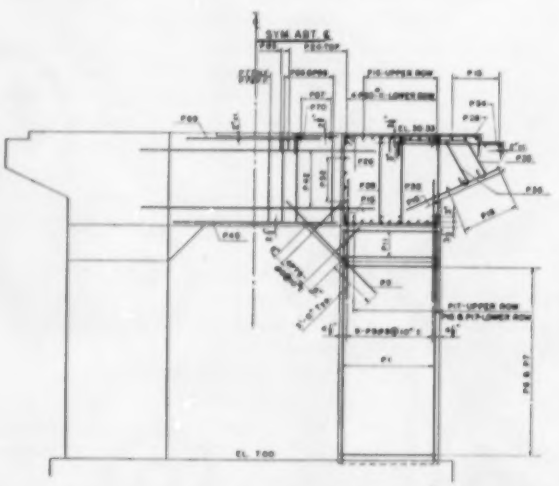
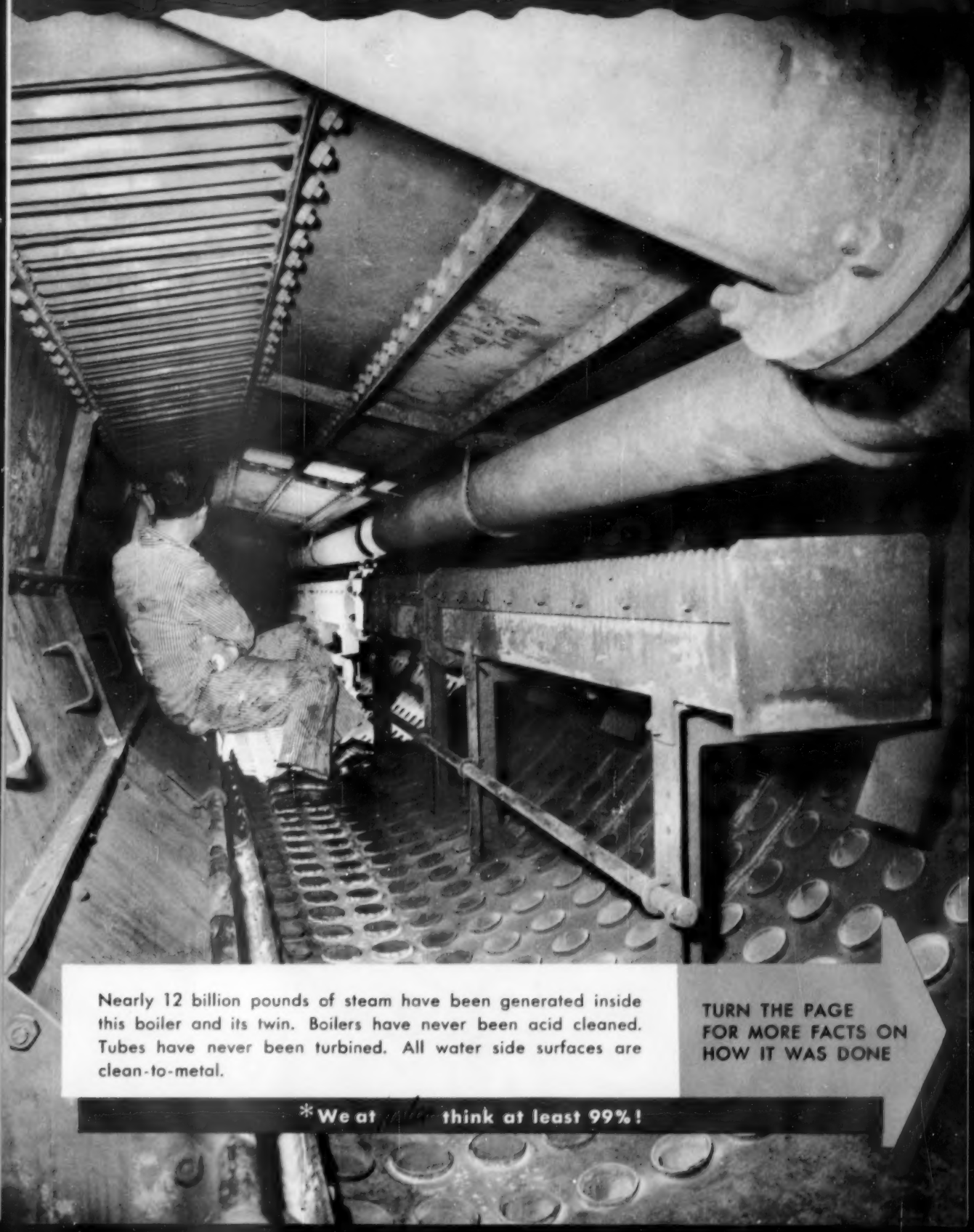


Fig. 6—Using symmetry to its maximum extent greatly simplifies the drawing of Fig. 5 and yet gives all the pertinent data for field needs

Proof of PERFECT* Water Treatment PERFORMANCE



Nearly 12 billion pounds of steam have been generated inside this boiler and its twin. Boilers have never been acid cleaned. Tubes have never been turbined. All water side surfaces are clean-to-metal.

TURN THE PAGE FOR MORE FACTS ON HOW IT WAS DONE

*We at [illegible] think at least 99%!

BOILER OPERATING DATA

● Two new boilers were put on line in a Southwestern municipal utility plant at the same time late in 1949. Rated capacity of each unit is 250,000 pounds of steam per hour at 950 p.s.i. Normal operating rates range from 150,000 to 175,000 pounds of steam per hour per unit.

The Nalco System of water treatment has been used continuously in these boilers. Raw water softening is by Nalcite* Ion Exchange Resins, and other Nalco products are used for after-treatment, internal treatment, and condensate return line protection. Results have been perfect. Boilers have never been turbined or acid cleaned, and are opened only for annual internal inspection.

*Registered Trademark

CLEAN . . . FOR TOP HEAT TRANSFER EFFICIENCY
What appear to be chalk marks in this unretouched photo are scrape marks which indicate only the usual powdery film left on the metal when the boiler is drained.

AND THE MUD DRUM IS SPOTLESS, TOO!
Another unretouched photo inside the mud drum of one of the boilers shows the like-new condition after years of service. No deposits or corrosion of any kind have been found in tubes or drums.

Nalco ON THE JOB

● Results like these are encountered every day in plants when the complete Nalco System of water treatment is on the job. The Nalco System is adaptable to old and new plants of any capacity, temperature, or pressure. Whether you operate a public utility or a space heating boiler, you will find your Nalco Representative of real assistance in the solution of your water treatment problems. Call him today, or write for full information.

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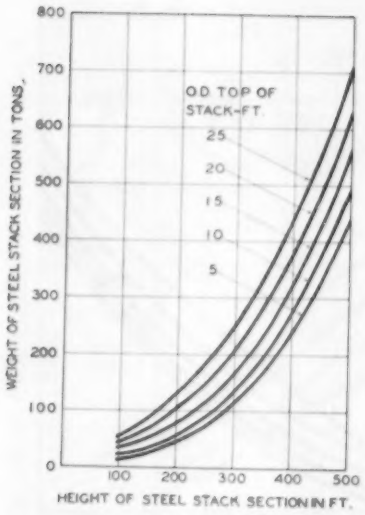


Fig. 1—Weight of steel in stack sections having an outside diameter at any section not less than $^1/_{11}$ the height of stack above that section

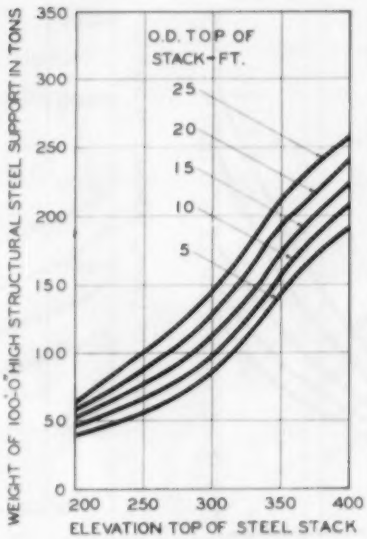


Fig. 2—Weight of structural steel required to support a steel stack

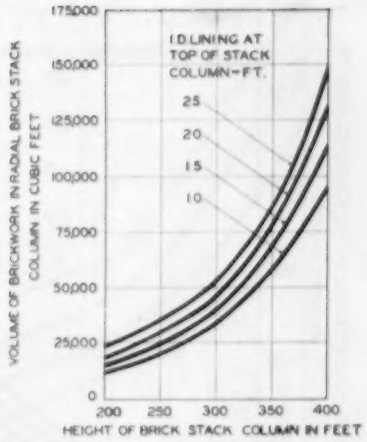

VOLUME OF BRICKWORK IN RADIAL BRICK STACK COLUMN IN CUBIC FEET
I.D. LINING AT TOP OF STACK COLUMN-FT.
25
20
15
10
HEIGHT OF BRICK STACK COLUMN IN FEET

Fig. 3—Brickwork volume for radial brick stack columns with brick linings for their full height and diameter expressed in terms of the inside diameter of the top of their linings

The Design and Comparative Costs for High Stacks*

By E. J. STANKIEWICZ

Sargent & Lundy

The improved dispersion of flue gases by increasing stack heights has introduced new problems and economic considerations for the engineer. These problems are reviewed in connection with our current practice for the design of steel, brick and concrete stacks. The relative costs of steel, brick and concrete stacks are discussed and charts presented for use in selecting the most economical type of stack.

DURING the past 20 years aerodynamic and meteorological investigations have been conducted to improve the dispersion of flue gases from steam generating power stations (1).† This work has determined the required stack heights for a given locality in order to keep the flue gas concentration at ground level within reasonable limits. In most cases this has resulted in higher stacks which have introduced structural problems concerning the vibration of tall structures under the action of wind forces. Due to the limited data available for use in analyzing the dynamic action of wind forces on stacks it was not immediately apparent that the excessive swaying and ovaling of certain steel stacks was a vibration problem that could not be solved by the use of conventional static wind loadings and the MC/I flexure formula (2, 3).

This paper discusses the vibration of steel stacks and reviews the current practice for designing steel, brick and concrete stacks. Economic factors entering into the selection of a particular type of stack are discussed and charts presented for use in obtaining comparative costs of steel, brick and concrete stacks.

Vibration of Steel Stacks

Two forms of vibration can take place in steel stacks. One form, cantilever vibration, is the periodic swaying of a stack perpendicular to the wind direction. The other form, ovaling vibration, is the periodic flattening of the circular shell of the stack.

Before the importance of considering vibration was recognized, design procedure consisted of converting a maximum expected wind velocity into an equivalent lateral pressure on the stack. Many steel stacks were designed for a lateral wind pressure of 30 lbs per sq ft on the projected stack area. This pressure approximates a 120 mph wind velocity. Using the 30 lbs per sq ft pressure, the stack plates and supporting structure were de-

* Presented at the Annual Meeting of the American Society of Mechanical Engineers, Nov. 28–Dec. 3, 1953, New York, N. Y.

† Numbers in parentheses refer to similarly numbered references in the Bibliography at end of paper.

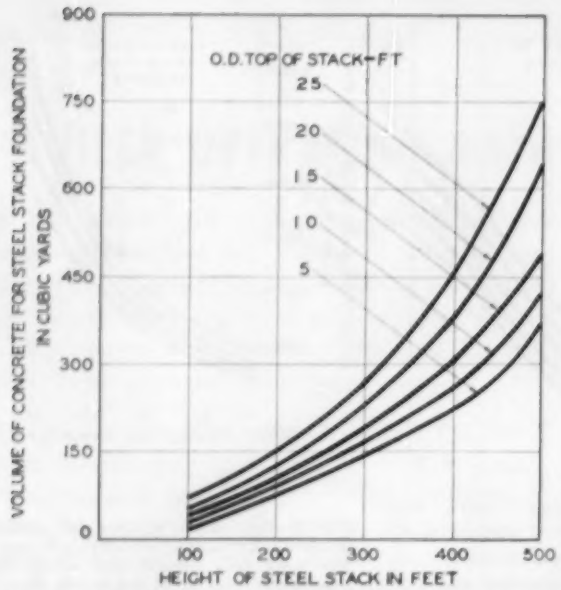


Fig. 4—Volume of concrete for steel stack foundations based on 6000 pounds per square foot soil pressure for various stack openings as indicated on curves

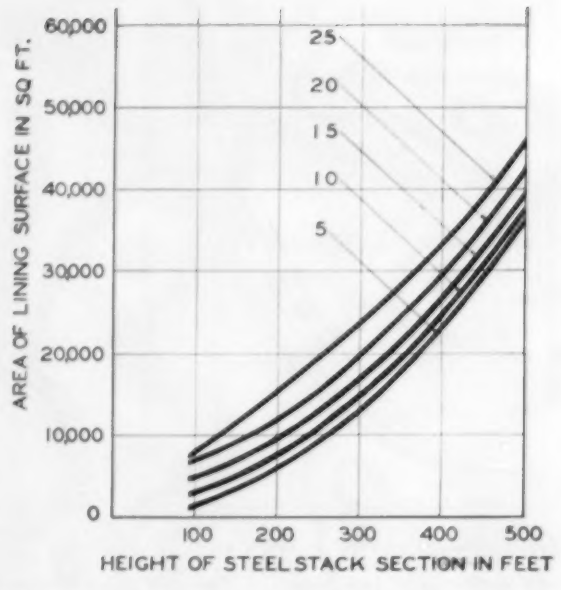


Fig. 5—Area of lining surface for steel stack sections having an outside diameter at any section not less than $^1/_{11}$ the height of the stack above that section

signed for stresses and overall deflections that were within established limits. No other aerodynamic effects were considered.

Based on the above design, low wind velocities in the range of 20 to 40 mph were expected to cause only slight deflections. These deflections were assumed to be in the same direction as the wind. Field observations of stacks exposed to low wind velocities often revealed vibration perpendicular to the wind direction with deflections that approached those expected from a 30 lb per sq ft lateral load.

Analysis of the wind forces revealed that when a stack obstructs an air stream, whirlpools of air called vortices form alternately on each side of the stack perpendicular to the wind direction. During the formation of each vortex, a negative pressure is built up until the vortex is shed. This negative pressure is the lateral load that pulls a stack from side to side perpendicular to the wind direction. The effect of this alternating load on the stack is dependent on the natural frequency of vibration of the stack and its supporting structure. Natural frequency of vibration is the rate at which the stack would vibrate if it could be struck like a tuning fork. As in the case of a tuning fork, amount of impact will not affect the frequency of vibration, only the amplitude of vibration.

A condition called resonance exists when the frequency of the alternating load due to vortex shedding equals the natural frequency of vibration of the stack. At resonance the amplitude of vibration increases radically. Amplitude of resonant vibration is further increased when a stack lies in the vortex trail of another stack that is within $3^1/_2$ to $5^1/_2$ diameters, center to center. Downwind stacks, therefore, tend to vibrate more than the upwind stack. The natural frequency of a stack combined with its supporting structure is usually determined by either the Ritz method (5) or some method of successive approximations. Calculated frequency normally checks within 10 per cent of actual field observations. With this frequency the resonant wind velocity can be found from the following formula:

$$v_r = \frac{df}{S} \qquad (I)$$

where:
- v_r = Resonant wind velocity in feet per second
- d = Diameter of stack in feet
- f = Natural frequency of vibration of stack combined with its supporting structure in cycles per second
- S = Strouhal Number, a dimensionless quantity found by field observation to generally range from 0.18 to 0.20

Resonant deflection and stresses are dependent on energy input due to the magnitude of the alternating lateral loads, the length of time the loads are acting and the damping forces in the entire structure. Damping forces dissipate the energy input of the wind. With no damping forces absorbing energy, the amplitudes of vibration would rapidly increase to failure when the stack is in resonance with the wind forces.

Resonant deflection and stresses can be determined if resonant wind velocity is converted to an equivalent lateral load by the following formula:

$$p_r = \frac{8.0mv_r^2}{10^6} \qquad (II)$$

where:
- p_r = Equivalent lateral load at resonance in lb per sq ft of projected area
- m = Magnification factor, dimensionless, ranging from 10 to 15 for lined steel stacks and 15 to 20 for unlined steel stacks.
- v_r = Resonant wind velocity in fps

The magnification factors are subject to more field observations. From the limited data now available the magnification for downwind stacks spaced $3^1/_2$ to $5^1/_2$ diameters can be taken as 15 for lined and 20 for unlined. Upwind stacks require a magnification factor of 10 for lined, 15 for unlined.

Brick and concrete stacks have very high moments of

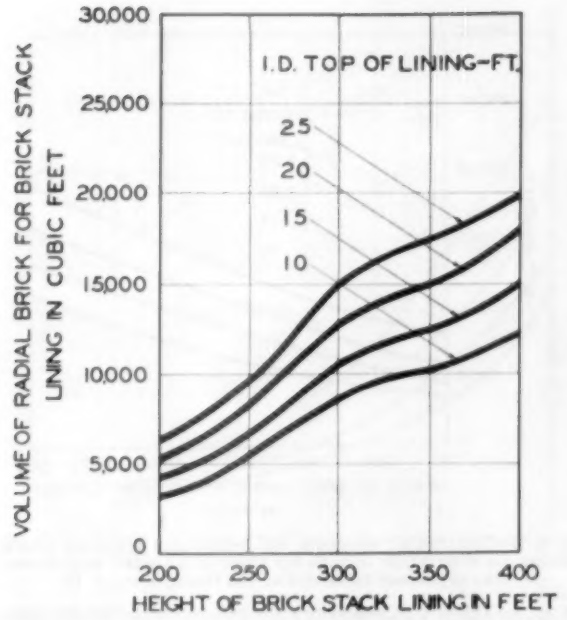


Fig. 6—Volume of radial brickwork for brick stack linings

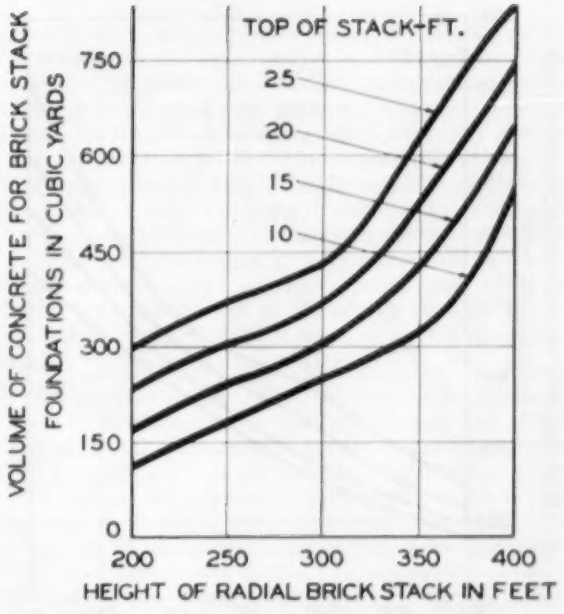


Fig. 7—Volume of concrete for radial brick stack foundations based on 6000 pounds per square foot soil pressure

inertia which substantially reduce deflection. In addition they have excellent damping characteristics. The combination of these two factors has permitted the design of brick and concrete stacks to be based on assumptions which do not require an investigation of the vibration forces such as are required for steel stacks. For the same reason a lined steel stack has better damping characteristics than an unlined steel stack. Riveted stacks have slightly better damping characteristics than welded steel stacks due to some yielding of the riveted joints.

Besides cantilever vibration, ovaling vibration must be considered. Ovaling vibration occurs when the frequency of the alternating wind loads are resonant with the natural frequency of vibration of the stack shell as a ring. The formulas necessary to determine the ring frequency are given by Timoshenko (5). From this frequency the velocity of the resonant wind can be determined from formula (I). A 100 mph wind velocity will cause ovaling when a $^1/_2$-in. unstiffened plate has about 13-ft 0-in. diameter or a $^3/_8$-in. unstiffened plate has about a 9-ft 0-in. diameter. Ring stiffeners should be used to keep the resonant wind velocity above the maximum expected wind velocity.

A typical example of cantilever vibration occurred at a mid-west power plant. Four identical stacks were erected on a common center line, spaced about 5 diameters apart. These stacks were 120 ft high with 9-ft 0-in. diameters and were supported by steel framing on the roof of the power plant. During erection, before the $2^1/_2$-in. gunite linings were installed, the downwind stacks vibrated. Amplitudes of 13 in. perpendicular to the wind direction were observed in a 20 mph wind that angled 20 degrees to the common center line. The magnification factor for this resonant deflection was found to be 15. The effect of adding the gunite lining was considered. It was found the lining would lower resonant wind velocity to about 15 mph. With the first mode of resonant vibration 15 mph the second mode of resonant vibration would be about 95 mph. Vibration at this velocity would be unsafe due to the large wind energy input.

In reviewing the stack supporting beams, it was decided to increase their depth by welding tees to their bottom flanges. This served three purposes. First it substantially reduced the deflection at the top of the stack due to the support beams. Secondly, stiffening the support beams raised the second mode resonant wind velocity to about 130 mph. Finally, although it raised the resonant wind velocity for first mode vibration of the lined stack to about 20 mph, the equivalent lateral load at this velocity was well under the design load. The stiffening added to the support beams plus the damping and stiffening from the lining minimized the amplitude of resonant vibration.

These stacks have now been in service for 7 years without any objectionable vibration re-occurring.

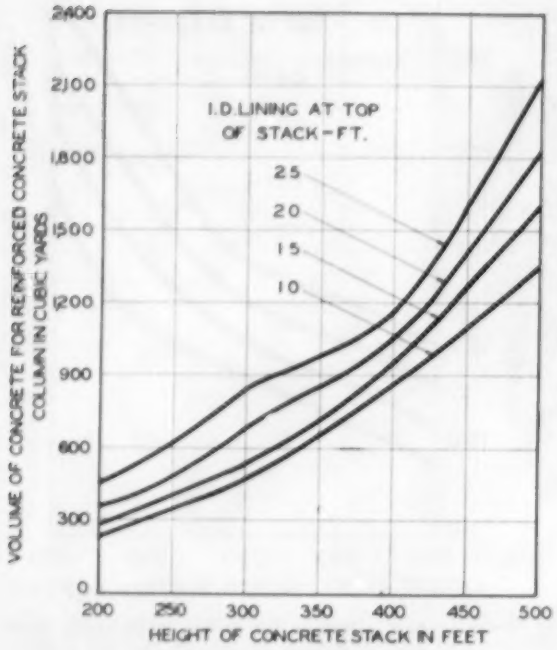
Design of Steel Stacks

Steel stacks are designed for the following static wind loading in lb per sq ft of projected area, 25 lb up to 150 ft above grade and 30 lb, 150 ft above grade and over. When subject to hurricanes and/or earthquakes the above stack loadings are modified to take care of the additional forces. The combined dead load and static wind load or combined dead load and earthquake load compressive stresses do not exceed $1^1/_3$ times the allowable stress given by the tubular column formula (6).

$$f_s = \frac{2{,}000{,}000}{D/t}\left[2 - {}^2/_3\left(\frac{200}{D/t}\right)\right] \qquad \text{(III)}$$

where:

f_s = Allowable unit stress, psi
D = Diameter of stack, in.
t = Plate thickness, in.



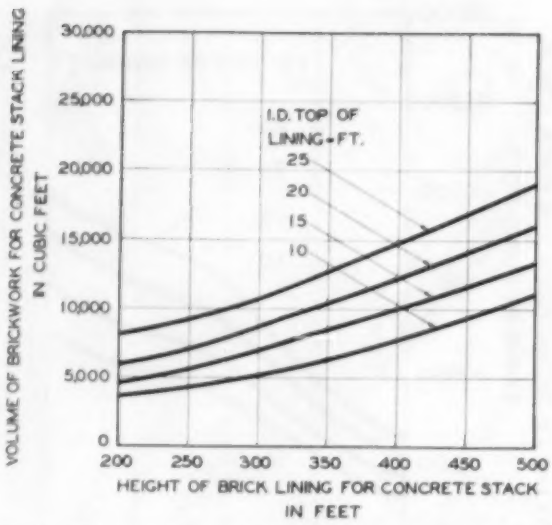


Fig. 8—Volume of concrete for reinforced concrete stack columns with brick linings for their full height and diameter expressed in terms of the lining's top I. D.

←
Fig. 9—Volume of brickwork for reinforced concrete stack linings

Steel stacks designed on the above basis and having a diameter at any section not less than one-eleventh the height of the stack above that section have, in general, been found to be satisfactory from the standpoint of excessive deflections due to cantilever vibration. As discussed above, the resonant wind velocity is determined and the corresponding equivalent lateral wind loads obtained for the lined and unlined stack to verify that the resonant wind loads for either condition do not exceed the assumed static wind loading. The maximum deflection of the stack is the sum of the deflection of the stack section as a cantilever beam, elongation of the anchor bolts, deflection of any supporting beams, change in length of any supporting columns and rotation of the foundation.

Welded steel stacks have lower maintenance costs than riveted stacks and in general have lower initial costs. Welded steel stacks constructed with a Structural Tee circumferential joint have the stem of the Tee projecting into the stack to support the lining and the flange of the Tee exposed on the outside face of the stack. The Tee is shop welded to the top of each course by fillet welds on the inside and outside of the stack plate and field welded to the bottom of each course by similar fillet welds on the inside and outside of the stack plate. The size of the Tee bar section is determined by the requirements for ovaling vibration as discussed above. The minimum size Tee is a ST 4-in. WF 10 lb section. Vertical joints are full penetration butt welds as high secondary bursting stresses are developed by the differential expansion between the lining and the stack plates. To help keep the stack deflections within reasonable limits, the maximum tension on the gross area of anchor bolts is 8000 psi and the depth of any supporting beams or girders are not less than one-sixth of their span.

The impact characteristics of ASTM Structural Steel, Grade A7, have not been satisfactory in a few isolated cases where brittle fractures occurred during and after repairs had been made to welded steel stacks. These fractures did not place the stacks in an unsafe condition; however, they did indicate that the construction of welded steel stacks has in part the same problems that the shipping industry has been working on for many years regarding the brittle fractures of welded ships. The American Bureau of Shipping Hull Steel, Class B, has a higher manganese to carbon ratio than ASTM Structural Steel, Grade A7. The resulting lower V-notched Charpy transition temperature of Class B hull steel makes it an ideal material for welded steel stacks. Structural steel plates furnished in accordance with ASTM Specification A283, Grade C, are widely used for pressure vessels and are more easily welded than Grade A7 plates. Either material is suitable for welded stacks; however, ASTM A283, Grade C, is to be recommended in preference to ASTM Grade A7.

Two types of linings are used for steel stacks. A 5-in. thick lining consisting of 4-in. thick vitrified paving brick with a 1-in. lumnite-silica sand mortar backing between the brick and the stack shell is one. A $2^1/_2$-in. thick lumnite-silica sand gunite lining reinforced with a heavy wire mesh anchored to the stack plates is a second.

No additional plate thickness is provided for the corrosion of lined stacks except the top course has a minimum $^3/_8$-in. plate thickness. Unlined stacks have a minimum corrosion allowance of $^1/_{16}$-in.

Design Of Brick Stacks

Many radial brick stacks for power plant service have been designed on the basis of an inside stack temperature of 600 F and an outside temperature of 10 F, and a wind load of 25 lb per sq ft of the projected area. Stacks subject to hurricanes have the wind load modified to take care of the additional forces. When the stack is subject to all the forces acting, the mortar tension does not exceed 20 psi and the mortar compression does not exceed 200 psi. The brickwork is laid in a mortar mix consisting

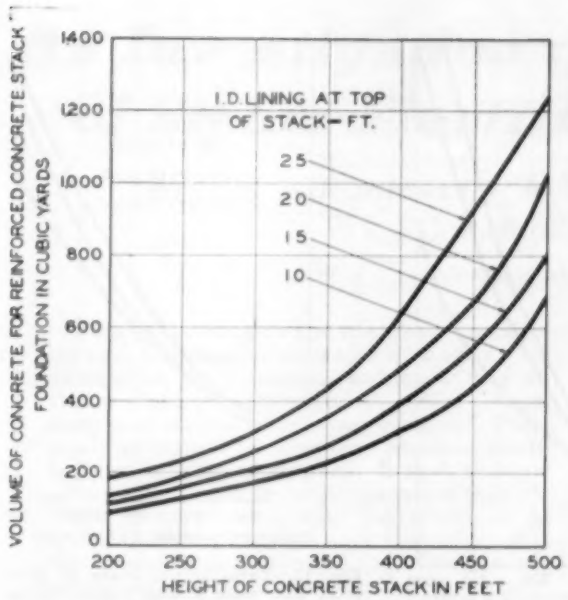


Fig. 10—Volume of concrete for reinforced concrete stack foundations based on 6000 pounds per square foot soil pressure

of one part portland cement, two parts lime and five parts of sand by volume. The brick work has a minimum weight of 120 lb per cu ft. The radial brick stack lining extends the full height of the stack and has a 2-in. minimum vented air space between the column and the lining. Radial brick stacks designed in accordance with the above conditions have sufficient mass to prevent any excessive swaying or vibration.

Design Of Concrete Stacks

The present practice is to design and construct concrete stacks for power plant service in accordance with the American Concrete Institute, "Standard Specification for the Design and Construction of Reinforced Concrete Chimneys" (ACI 505–54) for an inside stack temperature of 400 F. The brick lining extends the full height of the stack. When the space between the stack column and the lining is filled with insulation, the insulating material is fiber glass having a density of 6 lb per cu ft. Concrete stacks designed in accordance with the above specification have sufficient mass to prevent any excessive swaying or vibration.

Comparative Cost Of Stacks

The initial cost of stacks will vary considerably depending on material and labor costs and freight rates for different localities, as well as the variation in a given locality due to current price changes. By applying current unit prices to the material quantities obtained from the accompanying charts the estimated initial costs of steel, brick and concrete stacks can be determined. These estimated initial cost figures will require an adjustment to allow for the relative advantages of each particular type of stack construction. For example, a steel stack supported over a boiler should be credited with any reduction in the initial and maintenance costs of the flue gas duct work. Maintenance costs, outage time for maintenance, and flexibility for future alterations and extensions should be evaluated and the proper credits allocated to each type of stack construction. Maintenance charges will vary with local climatic conditions, stack gas temperatures, type of fuel, frequency of boiler outages or periods of partial loads, materials of construction, workmanship, and should be carefully analyzed for each installation. For example, an eastern utility company has found that the capitalized value of annual maintenance averaged over a 30 year period has in one instance shown that it might run approximately 3 per cent of the total cost of stack and foundation for a steel stack, from 5 to 16 per cent for a concrete stack and approximately 8 per cent for a brick stack (4).

The material quantities for determining the estimated costs of steel stacks can be obtained from the charts, Figs. 1, 2, 4, 5. The weights of steel stack sections given in Fig. 1 are based on nominal plate weights plus 15 per cent to allow for Tee bars or shelf angles, welds, coping, ladder, base connection and anchor bolts, allowable overweight of plates, material lost in fabrication and paint. The stack plates were designed to support a 5-in. thick brick lining and no additional plate thickness was allowed for corrosion. The unit cost per ton of stack section will range from $450 to $600. Fig. 2 is for use in obtaining average estimated weights of structural steel required to support a steel stack on the roof of a 100-ft high building or at 100-ft high independent steel tower. The estimated weight of structural steel to support a steel stack on the roof of a 150-ft high building or a 150-ft high independent steel tower is equal to the increase in weight for the 150-ft greater height of stack section. For example, the weight of a 150-ft high structural steel support for a 300-ft elevation top of stack above grade is obtained from Fig. 1 by taking the difference in weight between a 300-ft and a 150-ft. high stack section. The unit cost per ton of structural steel will range from $260 to $300. Fig. 4 gives the cubic yards of concrete for steel stack foundations. The unit cost per cubic yard, including excavation, formwork and reinforcing steel, ranges from $35 to $45. Fig. 5 gives the surface area of linings attached to the steel stack plates. When the breeching connection is located a considerable distance above the base of the stack, a false bottom protected with a lining and located immediately below the breeching opening is recommended in place of lining the "dead" space at the bottom of the stack. The unit cost per square foot for a 5-in. thick brick lining consisting of a 4-in. thickness of vitrified paving brick and 1-in. thick lumnite-silica sand mortar backing ranges from $2.25 to $2.75. The unit cost per square foot for a $2^1/_2$-in. thick lumnite-silica sand gunite lining with reinforcing is from $1.60 to $1.90.

The material quantities for determining the estimated costs of radial brick stacks can be obtained from the charts in Figs. 3, 6, 7 inclusive. Fig. 3 gives the volume of radial brickwork for stack columns. The unit cost per cubic foot for the radial brick stack columns, including mortar, step irons, cast aluminum air vents at top and bottom of each lining section, concealed steel reinforcing bands, cleanout door, lintels above breeching and cleanout doors; but not including steel breeching frames, bronze rail for obstruction lighting, lightning protection system and cast iron cap covering stack column and lining, ranges from $1.90 to $3.50. Fig. 6 gives the volume of radial brickwork for the stack linings. The

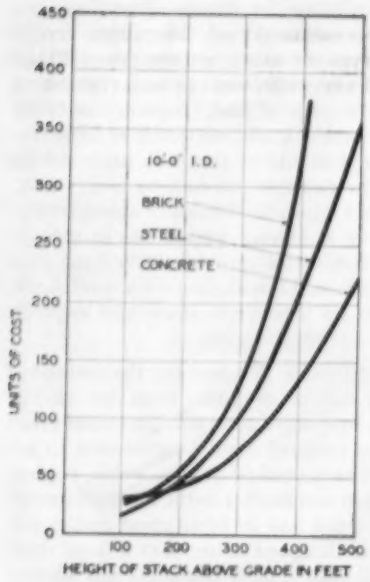


Fig. 11—Comparative total initial unit costs for 10-ft 0-in. I.D. steel, brick and concrete stacks

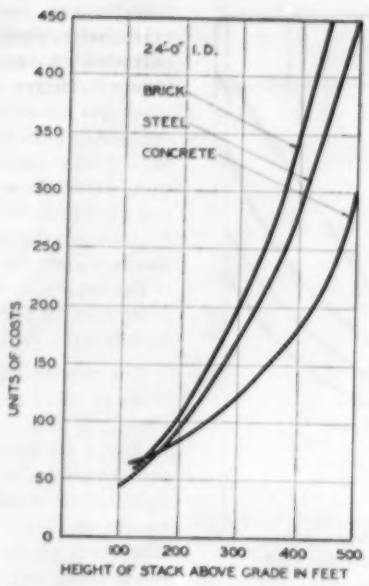


Fig. 12—Comparative total initial unit costs for 24-ft. 0-in. I.D. steel, brick and concrete stacks

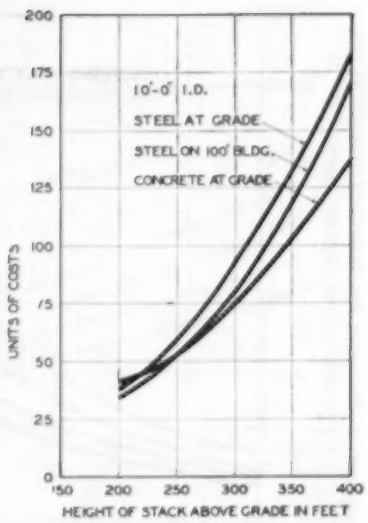


Fig. 13—Total initial costs of 10-ft 0-in. I.D. steel stacks supported on roof of 100-ft 0-in. high building compared with total initial costs of 10-ft 0-in. I.D. steel and concrete stacks supported at grade elevation

unit cost per cubic foot for the radial brick linings, including portland cement-lime mortar, ranges from $2.25 to $3.70. Fig. 7 gives the cubic yards of concrete required for brick stack foundations. The unit cost per cubic yard, including excavation, formwork and reinforcing steel, ranges from $35 to $45.

The material quantities for determining the estimated cost of concrete stacks can be obtained from the charts in Figs. 8 to 10 inclusive. Fig. 8 gives the volume of concrete for concrete stack columns. The unit cost per cubic yard of concrete including reinforcing steel, ladder and cleanout door, but not including lightning protection system and cast iron cap covering stack column and lining, ranges from $75 to $135. Fig. 9 gives the volume of hard burned shale brickwork for the concrete stack linings. The unit cost per cubic foot for the lining brickwork, including portland cement mortar and the cost of providing 2 in. of insulation or a 2-in. dead air space, ranges from $3.50 to $4.25. Fig. 10 gives the cubic yards of concrete required for concrete stack foundations. The unit cost per cubic yard including excavation, formwork and reinforcing steel, is from $35 to $45.

Discussion Of Comparative Initial Costs

The charts in Figs. 11 and 12 give an average total initial cost comparison for 10-ft 0-in. I.D. and 24-ft. 0-in. I.D. steel, radial brick and concrete stacks in terms of unit costs. The stacks are supported at grade elevation on concrete foundations designed for 6000 lb per sq ft soil pressure. All stacks have brick linings for their full height. The steel stack linings are vitrified paving brick laid in lumnite-silica sand mortar. The brick stack linings are radial brick laid in portland cement-lime mortar. The concrete stack linings are hard-burned shale brick laid in portland cement mortar and have 2-in. of fiber glass insulation or a 2-in. dead air space between the lining and the column. Lumnite gunite linings for steel stacks cost approximately one-third less than vitrified paving brick linings and this reduction in the cost of steel stacks will increase the height at which steel and concrete stack cost curves intersect.

The chart in Fig. 13 gives an average total initial unit cost comparison between a 10-ft 0-in. I.D. steel stack supported on the roof of a 100-ft 0-in. building and 10-ft. 0-in. I. D. steel and concrete stacks supported at grade elevation. The costs of the stacks supported at grade elevation have been taken from Fig. 11 and corrected for the omission of the lower 100-ft. 0-in. height of the brick linings. The cost of the brick lining represents a higher per cent of the total cost of steel stacks as compared to concrete stacks and the above reduction in lining surface has moved the intersection point, Fig. 13.

Acknowledgments

The material quantities and cost data for brick and concrete stacks were prepared by the Custodis Construction Company, Inc. Grateful acknowledgment is made to Messrs. L. Bordsoy, H. B. Schneider, F. P. Stray and J. Janush of their Chicago office.

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BIBLIOGRAPHY

(1) "The Control of Gases in the Wake of Smokestacks," R. H. Sherlock and E. A. Stalker. *Mechanical Engineering*, Vol. 62, 1940, 455–458.

(2) "The Case of the Vibrating Stack," D. J. Bergman. *Midwest Engineer*, May 1953, 11–12.

(3) "Aerodynamics and the Civil Engineer," W. Watters Pagon. *Engineering News-Record*, March 15, 1934; July 12, 1934; October 11, 1934; December 27, 1934; April 25, 1934; May 9, 1935; May 23, 1935, and October 31, 1935.

(4) "Economic and Design Considerations for Selection of Large Power Plant Stacks," H. L. Van Hohenleiten and R. H. Kent. COMBUSTION, Vol. 25, No. 1, 1953, 53–57.

(5) "Vibration Problems in Engineering," S. Timoshenko. Second Edition, 1937, 370–376, 405–406.

(6) "Formulas for Stress and Strain," R. J. Roark. Second Edition, 1943, 240–241.

An Investigation of the Economic Size of Steam-Electric Generating Units*

By L. K. KIRCHMAYER, A. G. MELLOR, J. F. O'MARA, and J. R. STEVENSON

General Electric Co.

This paper records the method of analysis and the results obtained of a study to determine the optimum economic size of steam-electric generating units that should be added to a power system. This study attempts to take into account such factors as size of system, forced outage rate, rate of load growth, installed cost of larger generating units, the effect of a maintenance program and the effect on the transmission system of the use of larger generating units. Out of the study comes the estimate that unit sizes of 500 to 600 mw will be economical in ten years.

A BASIC existing system of 2000-mw total generating capability was assumed for purposes of this study, consisting of twelve 25-mw units, twenty 50-mw units and seven 100-mw units. All units making up the basic system and all units added to the system, were assumed further, to be of the unit scheme type, that is, a single boiler to a turbine-generator set. Lastly the transmission system was considered adequately designed to carry the full output of the generating stations to the load areas.

Expansion of the system was carried out from the basic system of 2000-mw to a system of approximately 10,000-mw by means of four basic patterns:

1. 8 Per Cent Expansion

The size of units was kept within a band of 8 per cent to 5 per cent of the total installed capability of the system. This means, for example, that for the basic system of 2000-mw the first unit added to the system would be 8 per cent of 2000-mw or a 160-mw unit. This size of unit would be added every time new generation was required until the unit size was approximately 5 per cent of the total system generation, or, in this case, until the system generation totaled 3200-mw. When this point was reached, the next unit added would be 8 per cent of 3200-mw on approximately 250-mw.

2. 10 Per Cent to 7 Per Cent Expansion

The size of units added was kept within a band of 10 per cent to 7 per cent of the total capability of the system.

3. 15 Per Cent-to-10 Per Cent Expansion

The size of units added was kept within a band of 15 per cent to 10 per cent of system total capability.

4. 250-mw Expansion

The size of units added was initially kept within a band of 8 per cent to 5 per cent of the total installed capacity of the system up to units of 250-mw capacity, after which the system expansion was continued with 250-mw units regardless of system size.

To simplify the calculations, the unit sizes actually used were not exactly in accordance with the percentage bands indicated above. The sizes used were as follows and are shown in Figs. 1, 2, 3, and 4.

Expansion	Unit Sizes in MW
1. 8 per cent to 5 per cent	150, 250, 400, 600
2. 10 per cent to 7 per cent	200, 300, 400, 600, 900
3. 15 per cent to 10 per cent	300, 500, 800, 1200
4. 250-mw	150, 250

*Recommended by the AIEE Committee on Power Generation and presented at the Winter General Meeting of the American Institute of Electrical Engineers, New York, N. Y., January 31–February 4, 1955.

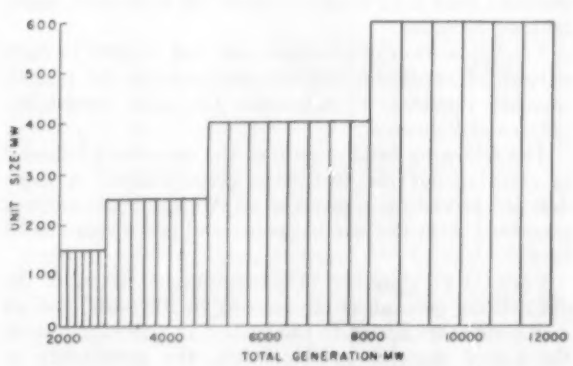


Fig. 1—Unit size is pictured as a function of total generation with an 8-to-5 per cent expansion program.

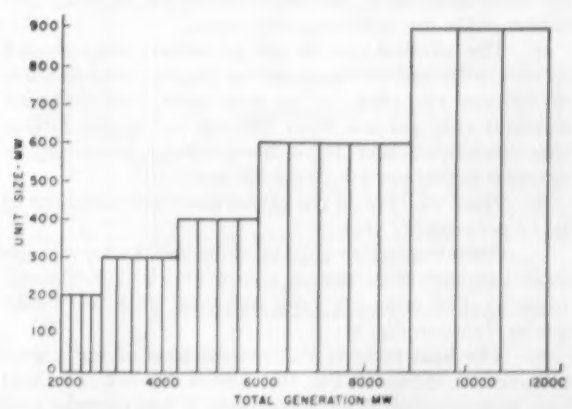


Fig. 2—Unit size in this case is figured as a function of total generation with a 10-to-7 per cent expansion.

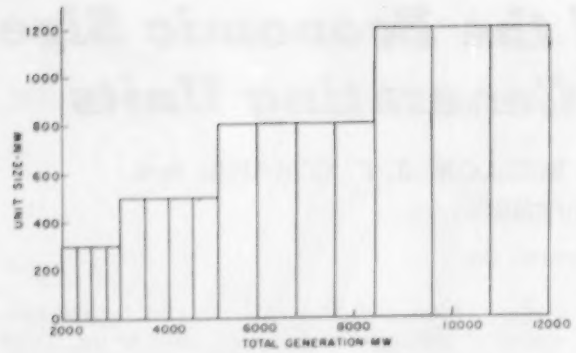


Fig. 3—Next assumed expansion employed a unit size based on total generation with 15-to-10 per cent expansion.

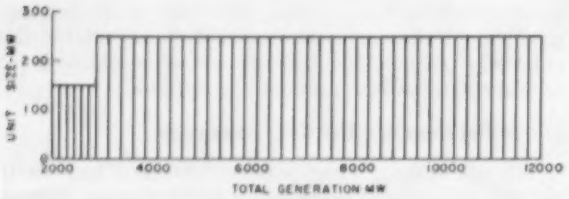


Fig. 4—Last expansion plan assumed employed a unit size of 250-mw as a top size and this is shown above.

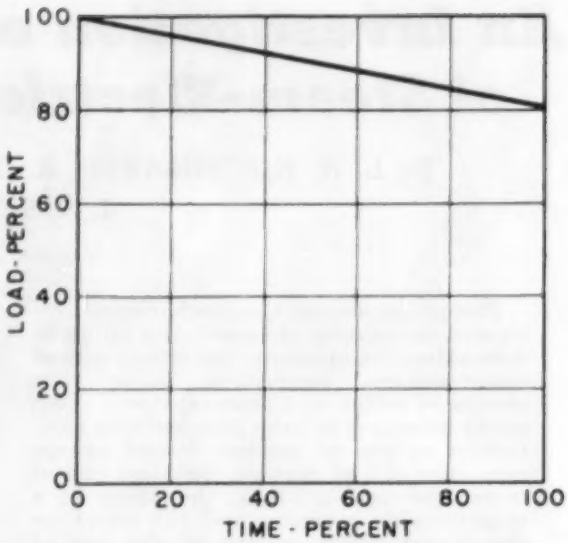


Fig. 5—Variation in system weekday peak load throughout the year was assumed to be a straight line as above.

Assumptions

1. It was assumed that the standard of reliability of the power system was such that sufficient generating capacity would be available so that the probability of loss of load would be one day in eleven years.

2. A combined forced outage rate of 2 per cent for the generating unit (combined boiler and turbine-generator set) was assumed. This is in line with recent experience on generating units. To determine the effect of a possible lower reliability of very large units, a forced outage rate of 3 per cent was assumed in some cases.

3. It was assumed that each boiler-turbine-generator unit on the system would be out of service for twenty weekdays a year for planned maintenance.

4. The variation in system weekday peak load throughout the year was assumed to be a straight line from 100 per cent to 80 per cent as shown in Fig. 5. This is reasonably typical for most power systems except for some systems in the south where the summer and winter peaks are approximately equal.

5. The installed cost of new generation was assumed to vary with unit size as shown in Fig. 6. Above a size of 200-mw two cost curves were used, one assuming constant cost per kw from 200-mw up to the largest size considered, and the other showing a continuing decrease in cost per kw above 200-mw.

6. Fixed charges on the investment were assumed to be 12 per cent per year.

7. Operating labor cost in mills per kwhr was assumed to vary with size as shown in Fig. 7. Maintenance cost in mills per kwhr was assumed to vary with size as shown in Fig. 8.

8. The heat rates of the various sizes of units were assumed as shown in Fig. 9. Above 200-mw, the heat rate was assumed to be constant as it was thought that these larger units would all use the maximum practical steam conditions and that no improvement in heat rates would be realized only from increased size. It is realized that unit heat rates, particularly in the larger size units, will almost certainly continue to improve in the future and this improvement will make the use of larger generating units more attractive.

9. Fuel was assumed at 25 cents per million Btu.

10. The load duration curve of the system was assumed to be as shown in Fig. 10. This curve is based on a system load factor of 60 per cent which is typical of many large power systems.

11. The fuel and operating costs of units on spinning reserve with negligible load were neglected.

Method of Analysis

The method used to determine the most economical pattern of system expansion consists essentially of two parts:

1. Determination of the reserve capacity required on the system to maintain the assumed standard of reliability for each pattern of system expansion, taking into account the following factors: (*a*) size of generating units, (*b*) forced outage rate of generating units, (*c*) weekday peak load duration curve, (*d*) a planned maintenance program.

2. Application of the assumed cost factors to each pattern of expansion (taking into account the reserve capacity required) to determine the most economical pattern of expansion.

The following briefly outlines the procedure followed in carrying out the two steps given above. A more detailed procedure is given in an Appendix the authors presented with the original paper and is not reproduced here.

For each combination of generators, consisting of the old existing generators (amounting to 2000-mw) and all new generators added to the system in accordance with the above patterns of expansion, the probability of availability of particular amounts of generation was determined. This was done for each pattern of expansion using a 2 per cent forced outage rate and also

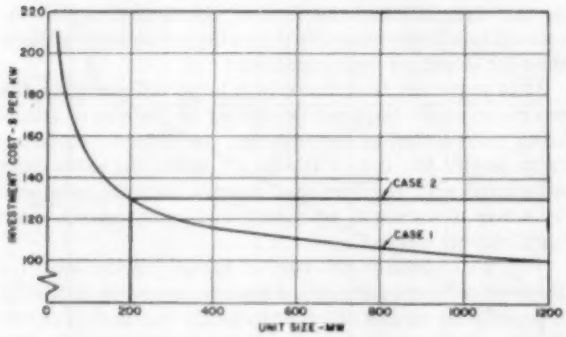


Fig. 6—Investment cost is pictured as a function of unit size.

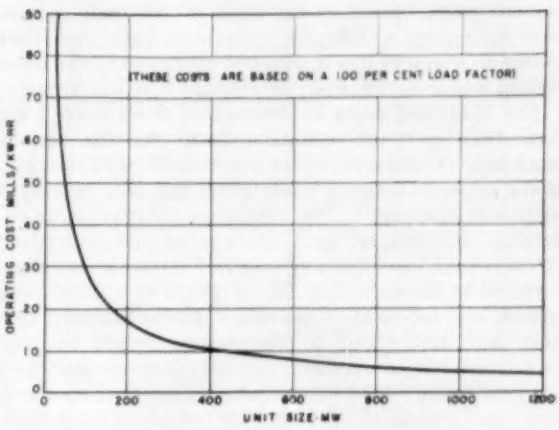


Fig. 7—Operating cost is represented as a function of unit size.

for the 8 per cent-to-5 per cent and 10 per cent-to-7 per cent patterns of expansion using a forced outage rate of 3 per cent for all units over 250-mw. Since the smallest unit on the system was 25-mw, the probability of availability was determined in 25-mw steps to the point at which the probability of availability was practically zero (actually 0.00000001).

It was necessary to take into account a program of planned maintenance which would require each generating unit to be out of service for 20 weekdays per year. In planning this maintenance program, the weekday peak load throughout the year was assumed to vary as a straight line from 100 per cent to 80 per cent, Fig. 5.

As far as system reliability is concerned, it was assumed that the total load can be considered as the actual system load plus the capability of generation out of service for maintenance. Therefore using the peak load variation curve referred to above, the maintenance period of each machine on the system was scheduled in such a manner that the sum of the actual load and the capability of units out for maintenance at any time was kept as uniform as possible.

When this maintenance program had been established, three different loads were assumed for each amount of total installed generating capacity. Using the probability of availability factors previously determined for each combination of generating units, it was then possible to determine for each of the assumed loads, how many days per year there would be insufficient generating capacity available to meet the load. From these data, curves could be drawn, similar to Fig. 11, indicating the probability of loss of load as a function of load for each value of installed generating capacity.

First, it was assumed that whenever a new generator was added to the system the system load was immediately increased (either within the system or by sale to outside utilities) to the point where the probability of loss of load again was one day in eleven years. This method essentially eliminates the factor of rate of load growth.

The next step was to associate the load carrying capabilities of the various generator combinations with the rates of load growth for the country, three rates were chosen: load doubling in 5, 10 and 15 years. Starting with a basic system of 2000-mw capability of generation, the load for each year was calculated for each rate of load growth until the system load was approximately 10,000-mw. In order to strictly adhere to a one day in eleven years loss of load probability, it was necessary, in some cases, to add a large block of generation when only a few additional megawatts of reserve were required. To be practical, in these cases, the standard of reliability was reduced to a minimum of one day in seven years. No maximum standard of reliability was specified.

Table I shows a tabulation of costs and the method of calculating total annual cost of generating power in mills per kwhr. These costs are based on the assumed curves of Figs. 6, 7 and 8 for investment, operating and main-

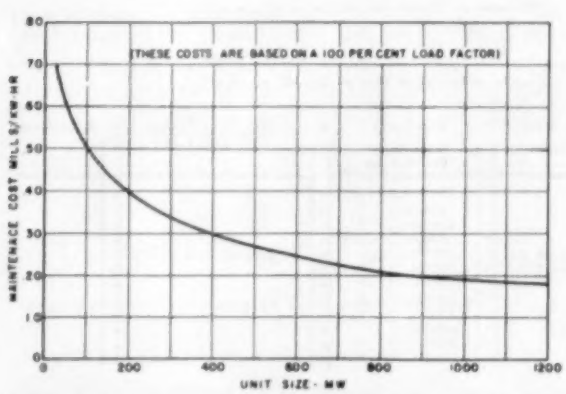


Fig. 8—Maintenance cost shown as a function of unit size.

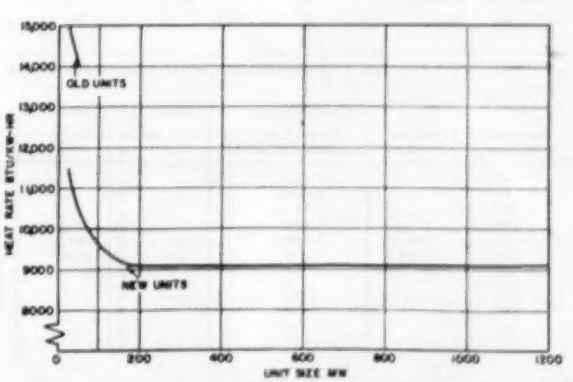


Fig. 9—Heat rate as a function of unit size traces this curve.

tenance costs. Some of the units of the basic system were figured at a different investment rate than that shown on Fig. 6 as it was assumed that most of the basic system was installed when investment cost was lower.

The operating costs as determined from Table I are dependent upon the utilization factor for the various machines. Utilization factor can be defined as the ratio of the kilowatt-hours actually generated in a year by a particular machine to the maximum kilowatt-hour capability of the machine. To calculate the utilization factor of each machine, a system load duration curve was assumed as shown in Fig. 10. This curve is based on a system load factor of 60 per cent. It was assumed that each new unit added to the system would be base loaded. With a maintenance period of twenty weekdays per year and a forced outage rate of 2 per cent, each new unit could supply about 90 per cent of its total kilowatt-hour capability. By filling in the area under the load duration curve with line generators associated with a particular load, the utilization factor for each size machine on the system was determined.

Discussion of Results

Figs. 12 and 13 are plots of the installed generation required to meet various loads with a probability of loss of load of one day in eleven years and one day in seven years respectively. These curves are for each of the various patterns of expansion studied and take into account a program of planned maintenance. These curves do not consider the effect on the capacity requirements of the load variations that result from changing business and weather conditions. It was found that when the effect of these load variations is included in the calculations, the reserve requirements are increased to a larger extent with smaller per cent expansions than for larger per cent expansions.

It is apparent that there is a large difference in the reserve capacity required depending on the size of generating units added to the system. In order to economically justify the use of the larger units, the extra costs associated with the increased reserve must be overcome by lower investment, operating and maintenance costs for the larger units.

Fig. 14 compares the cost of supplying the load for the four different patterns of system expansion assuming a probability of loss of load of exactly one day in eleven years. These curves are based on the assumption that the forced outage rate is 2 per cent regardless of size and that the installed cost of new units continues to decrease as size increases. For the assumed conditions the cost curve using units of 15 per cent-to-10 per cent of system size falls below the cost curve using units 10 per cent-to-7 per cent of system size for system loads above 5500-mw.

The effect of assuming that the installed cost per kw of units above 200-mw remains constant regardless of size is shown in Fig. 15. These curves indicate that for this condition, expansion with 250-mw units is generally most economical.

The results shown in Fig. 14 indicate that the most economical pattern of system expansion is very dependent on the investment cost of larger generating units. It is apparent that the future slope of the cost per kw vs. size curve will be a major factor in determining the economic feasibility of larger generating units.

The effect of an increase in the forced outage rate of generating units larger than 250-mw from 2 per cent to 3

TABLE I Case 1 ($/kw costs taken from Fig. 9) Mills/kw-hr for each generator size = Base Cost (Total Capacity-kw/peak load-kw x LF)

Generator Size-mw	Investment Costs $/kw	Fixed Charges Mills/kw-hr 12%($/kw)10³/8760	+	Operating Mills/kw-hr	+	Maintenance Mills/kw-hr	+	Fuel Costs(UF)= Mills/kw-hr	=	Base Costs Mills/kw-hr Per Machine	x	No. Machines x Machine Rating-mw / Peak Load x LF	=	Mills/kw-hr
25	140.00*	1.91781	+	0.900	+	0.700	+	3.75000(UF)	=	3.51781+3.75 (UF)	x	N x 2525/peak load x 0.6	=	
50	120.00*	1.64384	+	0.500	+	0.600	+	3.50000 "	=	2.74384+3.5 "	x	N x 5050/ " " " "	=	
100	128.60**	1.76164	+	0.300	+	0.500	+	2.40000 "	=	2.56164+2.4 "	x	N x 100/ " " " "	=	
150	118.00	1.89041	+	0.217	+	0.443	+	2.31998 "	=	2.55041+2.32 "	x	N x 150/ " " " "	=	
200	130.00	1.78082	+	0.170	+	0.400	+	2.27500 "	=	2.35082+2.275 "	x	N x 200/ " " " "	=	
250	125.00	1.71233	+	0.145	+	0.367	+	" "	=	2.22433+ " "	x	N x 250/ " " " "	=	
300	121.00	1.65753	+	0.126	+	0.340	+	" "	=	2.12353+ " "	x	N x 300/ " " " "	=	
400	116.00 ***	1.58904	+	0.100	+	0.300	+	" "	=	1.98904+ " "	x	N x 400/ " " " "	=	
500	113.00	1.54920	+	0.090	+	0.275	+	" "	=	1.91420+ " "	x	N x 500/ " " " "	=	
600	110.00	1.50684	+	0.070	+	0.250	+	" "	=	1.82684+ " "	x	N x 600/ " " " "	=	
800	106.00	1.45205	+	0.060	+	0.210	+	" "	=	1.72205+ " "	x	N x 800/ " " " "	=	
900	104.00	1.42466	+	0.055	+	0.195	+	" "	=	1.67466+ " "	x	N x 900/ " " " "	=	
1200	100.00	1.36986	+	0.060	+	0.180	+	" "	=	1.58986+ " "	x	N x 1200/ " " " "	=	
												Total Mills/kw-hr		

* Based on old costs ** Based on 3 gen. at $100 and 4 gen. at $150 *** Based on present and estimated future costs

Case 2 (Same as Case 1 except that investment cost for all units above 200 mw kept at the 200 mw level)

Generator Size-mw	Investment Costs $/kw	Fixed Charges Mills/kw-hr 12%($/kw)10³/8760	+	Operating Mills/kw-hr	+	Maintenance Mills/kw-hr	+	Fuel Costs(UF)= Mills/kw-hr	=	Base Costs Mills/kw-hr Per Machine	x	No. Machines x Machine Rating-mw / Peak Load x LF	=	Mills/kw-hr
25		1.91781	+		+		+		=	3.41781+3.75 (UF)	x		=	
50		1.64384	+		+		+		=	2.74384+3.5 "	x		=	
100		1.76164	+		+		+		=	2.56164+2.4 "	x		=	
150		1.89041	+		+		+		=	2.55041+2.32 "	x		=	
200	Same as	1.78032	+	Same as	+	Same as	+	Same as	=	2.35082+2.275 "	x	Same as Case 1	=	
250	Case 1	"	+	Case 1	+	Case 1	+	Case 1	=	2.29282+ " "	x		=	
300		"	+		+		+		=	2.24682+ " "	x		=	
400		"	+		+		+		=	2.18082+ " "	x		=	
600		"	+		+		+		=	2.10082+ " "	x		=	
800		"	+		+		+		=	2.05082+ " "	x		=	
900		"	+		+		+		=	2.03082+ " "	x		=	
1200		"	+		+		+		=	2.00082+ " "	x		=	

Tabulation of costs and the method of calculating total annual costs of generating power in mills per kwhr, shown above, are based on the assumed curves of Figs. 6, 7, and 8, for investment, operating and maintenance costs.

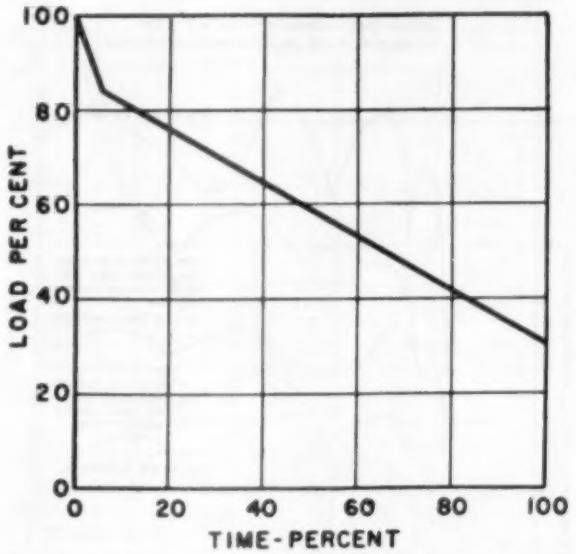


Fig. 10—Load duration curve for a 60 per cent load factor

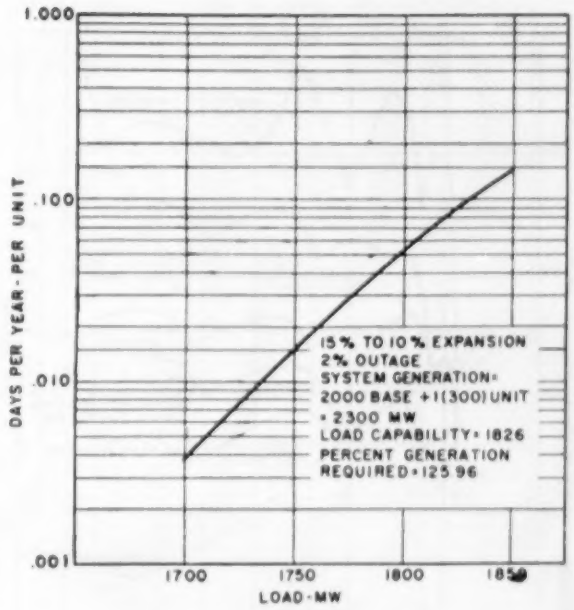


Fig. 11—Probability of loss of load as a function of load

per cent is shown in Fig. 15 for three plans where the investment cost per kw continues to decrease as size increases. The study shows it is more economical to expand the system with 250-mw units than with units of either 8 per cent-to-5 per cent or of 10 per cent-to-7 per cent of the system size, if the forced outage rate for units greater than 250-mw increases to 3 per cent. If machines much larger than those produced today are to be economically justified their forced outage rates must be approximately the same as those of present machines.

A comparison can be made of the cost of power in mills per kwhr using the two different assumptions for installed cost of generation as shown in Fig. 9. One comparison studied was for an 8 per cent-to-5 per cent of expansion using a forced outage rate of 2 per cent.

When the rate of system load growth is taken into account, the results are not so clearly defined as were the results obtained by assuming that whenever a new generator was added to the system the system load was immediately increased (either within the system or by sale to outside utilities) to the point where the probability of loss of load was one day in eleven years. When the load follows a particular pattern of increase, each generator added causes a peak in the cost curve, the magnitude of which is dependent upon the percentage of the generator output that is actually required by the load.

To effect the comparisons between the various patterns of expansion when considering different rates of load growth, present worth evaluations were utilized. In brief, the present worth figure for a given expansion indicates the total amount of money that would have to be available at the present time to completely finance the investment and operating costs of the generation under consideration for a given period of time.

A summary of the relative costs of the different patterns of system expansion on a present worth basis using an interest rate of 4 per cent is shown in Table II. The figures in the table indicate the percentage of in-

TABLE II COST OF VARIOUS EXPANSION PATTERNS Expansion from 2000 MW to Approx. 10,000 MW System

Load Doubles in N Years N	Investment Cost Case #	250 MW	8% - 5%	10% - 7%	15% - 10%	8% - 5% *	10% - 7% *
5	1	0.76	0.51	Base[1]	1.52	1.68	
	2	1.52	1.98	2.48	6.43	3.30	
10	1	1.01	0.97	Base[2]	1.54	1.84	1.96
	2	1.71	2.10	2.13	5.93	3.23	4.38
15	1	0.44	0.30	Base[3]	0.95	0.77	
	2	1.11	1.58	2.18	5.23	2.10	

Figures are % increase in cost over base case

Case #1 — Decreasing investment cost.
Case #2 — Flat investment cost after 200 MW.

* - Outage rate 3% for machines over 250 MW.

Note 1 - Base = 1.355 billion dollars
2 - Base = 2.068 billion dollars
3 - Base = 2.624 billion dollars

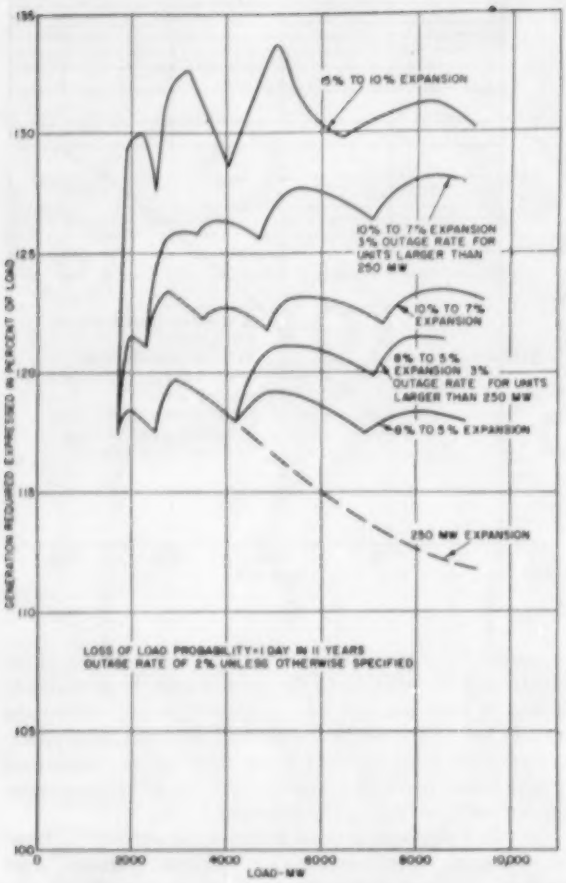


Fig. 12—Assuming a loss of load probability of one day in eleven years system reserve shows in curve above.

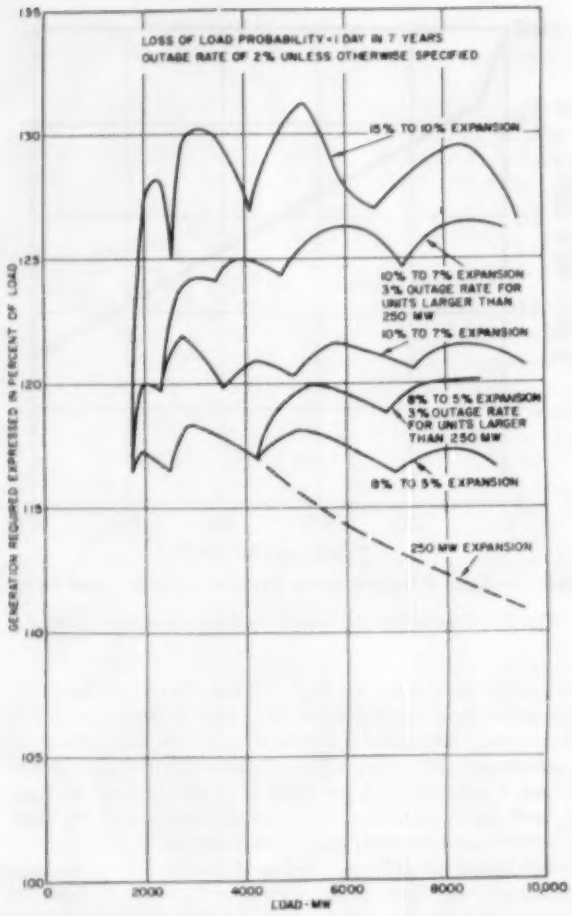


Fig. 13—Same curve as Fig. 12 of system reserve for a loss of load probability of one day in seven years.

crease in cost over the indicated base case. (Table p. 61.)

The cost comparisons given in Table II can also be shown graphically for a forced outage rate of 2 per cent. The results for the three different rates of load growth all lie within a narrow band of results. This same information has been plotted for a 3 per cent outage rate.

Effect of Improvement in Station Heat Rate

In all the comparisons made above, the heat rates of all new generator units added to the system were assumed to be as given by Fig. 9; and no heat rate improvements in this curve resulting from future technological advances were considered in our calculations. However, it can reasonably be expected that there will be a continued improvement in station heat rates in the future as there has been in the past. This improvement in station heat rate will make larger units more attractive economically. The reason for this is that each new unit added to the system will be base loaded during the early years of operation and so the load on the older, less efficient units can be reduced. The larger the new unit that is added, the greater the fuel saving realized on the older units and this fuel saving can be used to more than offset the extra costs incurred due to the extra reserve required for the larger units.

Effect of Larger Units on Transmission Costs

In the results presented so far only the total costs of generating power have been considered. However, the use of very large generating units will require additional transmission facilities to provide support in case of planned or forced outages of a generating unit. It is estimated that for a widespread, well-designed system, the incremental cost of providing such additional transmission facilities will be between $10 and $20 per kw of installed capacity for 1000-mw generating units as compared to 250-mw generating units.

To explore the effect of the cost of providing additional transmission facilities for the larger units, two cases were considered by modifying the investment costs of units as a function of unit size as follows:

1. The penalty in cost for supplying additional transmission facilities was assumed to vary linearly from $0 per kw for 250-mw units to $10 per kw for 1000-mw units.

2. The penalty in cost for supplying additional transmission facilities was assumed to vary linearly from $0 per kw for 250-mw units to $20 per kw for 1000-mw units.

Interconnecting transmission facilities between systems can often be economically justified on the basis of economical power interchange and of the reduction in total reserve capacity required on the combined systems.

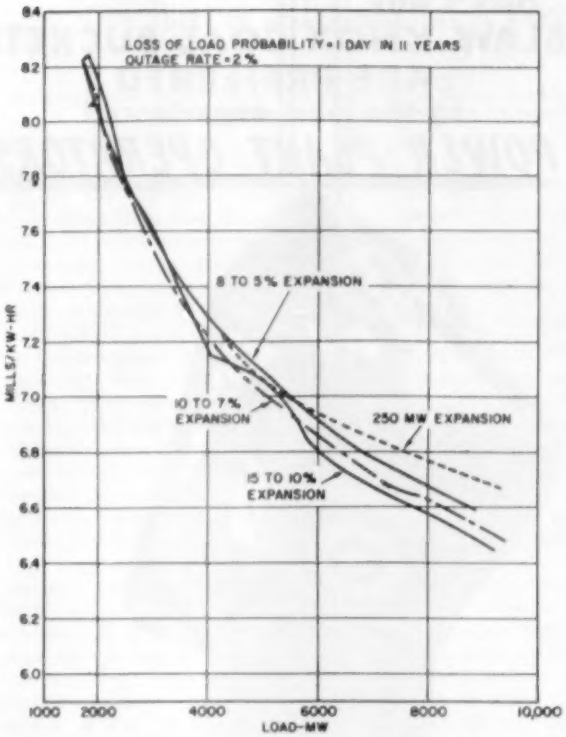

LOSS OF LOAD PROBABILITY = 1 DAY IN 11 YEARS
OUTAGE RATE = 2 %
8 TO 5% EXPANSION
10 TO 7% EXPANSION
250 MW EXPANSION
15 TO 10% EXPANSION
MILLS/KW-HR
LOAD-MW

Fig. 14—Cost comparisons are pictured above for costs of supplying load under the four methods studied

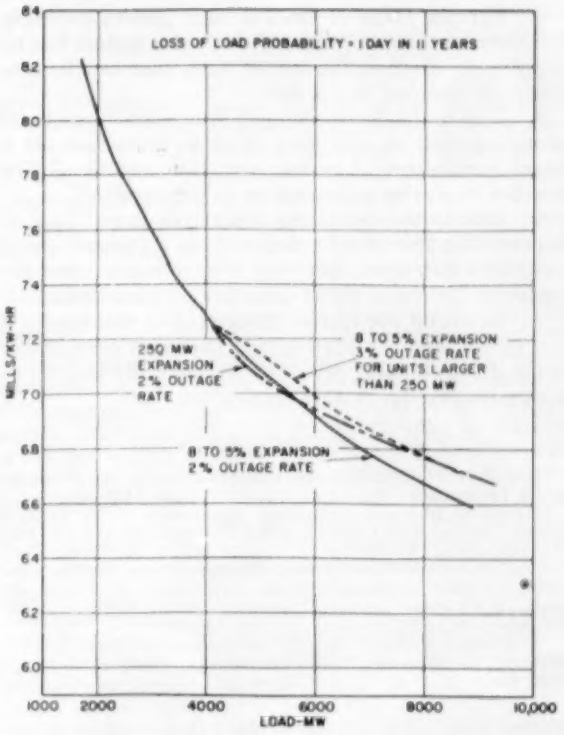

LOSS OF LOAD PROBABILITY = 1 DAY IN 11 YEARS
250 MW EXPANSION 2% OUTAGE RATE
8 TO 5% EXPANSION 3% OUTAGE RATE FOR UNITS LARGER THAN 250 MW
8 TO 5% EXPANSION 2% OUTAGE RATE
MILLS/KW-HR
LOAD-MW

Fig. 15—The effect of increase in outage rate from 2 to 3 per cent for units is pictured here

Depending on the capacity of such interconnections, the systems approach one large system and larger generating units can often be economically justified. But any appreciable extra cost in the transmission system considerably reduces the attractiveness of larger units.

Application to a Smaller Power System

In this case an initial system of 1000-mw of installed capacity consisting of twelve 12.5-mw units, twenty 25-mw units and seven 50-mw units was assumed. The load on the system was assumed to double every ten years and was expanded from a 1000-mw system to approximately a 5000-mw system. Again the expansion pattern of using generating units of 10 per cent-to-7 per cent of system size was found to be the most economical but the reduction in cost by using this pattern rather than smaller units is greater for the smaller system. This result was obtained because the slope of the cost per kw vs. size curve is steeper in the lower size range. There is, therefore, a greater gain in using units that are a higher percentage of system size on a small system than on a large one.

Summary of Factors

The factors in favor of and against the use of large generating units may be summarized as follows:

Factors Favoring Large Units

1. A steep slope of the curve of cost per kw vs. size.
2. Lower operating and maintenance costs per kwhr for larger units.
3. Further improvement in station heat rate resulting from technological advances.
4. Reduction in the number of construction and maintenance crews required with larger units.
5. Interconnections with adjoining systems.

Factors Against Large Units

1. Flat slope of the curve of cost per kw vs. size.
2. Increased reserve capacity required with larger units.
3. Any increase in forced outage rate.
4. Increase in capacity required in the transmission system.
5. Site limitations.

Conclusions

Based on the assumptions made in this study, the following trends may be noted from the results obtained:

1. If the investment cost of large units continues to decrease with size and the forced outage rate for large units remains at the present level (2 per cent or lower), the most economical pattern of system expansion is to add units of between 10 per cent-and-7 per cent of the size of the system studied. The slope of the curve of cost per kw vs. size is the determining factor rather than the absolute values of investment cost.
2. If above any size the investment cost in dollars per kw remains constant, there will be very little incentive to use units above this size.
3. Any increase in the forced outage rate of large units will slow up the move to these large units.

4. For the range of rates of load growth normally encountered the rate of load growth of a system has no appreciable effect on the size of units that can be economically justified on a system.

5. Due to the decreasing gain in investment cost and operating costs as unit sizes increase, units that are a larger percentage of system size can more easily be justified on smaller systems than on large systems.

6. Due to the decreasing gains from larger units, it appears that the rate of increase of the maximum size of units may slow down, but there is no indication that the maximum economic size of units has yet been reached.

7. Based on the factors considered in this study, it can be conservatively estimated that unit sizes of the order of 500- to 600-mw will be economically utilized on some power systems within the next ten years.

REFERENCES

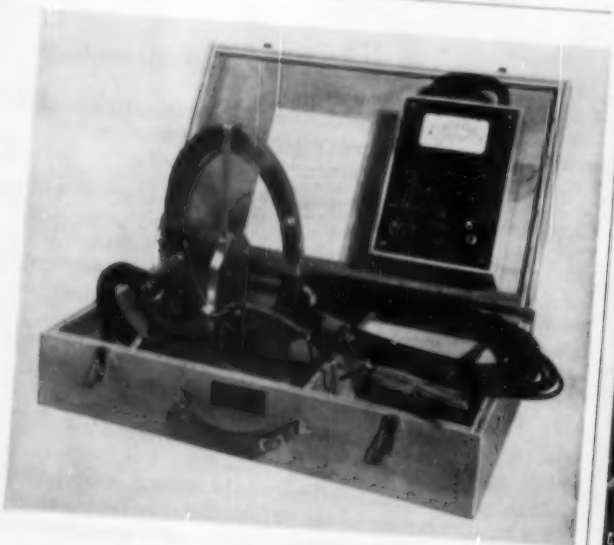
"Elements of System Capacity Requirements," C. W. Watchorn, *AIEE Transactions*, Vol. 70, Part II, 1951, pages 1163–80.

"Tables of Binomial Probability Distribution to Six Decimal Places," (Committee Report), *AIEE Transactions*, Vol. 71, Part III, 1952, pages 597–620.

"Forced Outage Rates of High Pressure Steam Turbines and Boilers," Joint Subcommittee on Application of Probability Methods to Power System Problems. AIEE Paper No. 54–320 presented at Fall General Meeting, October 1954.

"Generating Reserve Capacity Determined by the Probability Method," G. Calabrese, *AIEE Transactions*, Vol. 66, 1947, pages 1439–50.

Editors Note: The full text of this paper is available from the AIEE as paper No. 55–183.



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What's Ahead in Power?*

By Theodore Baumeister,
Stevens Professor of Mechanical Engineering, Columbia University; Consulting Engineer, General Public Utilities Corporation

ANY engineer who is asked to look ahead in his field of specialization is bound to have his imagination stirred. Inherently, he must always be looking for something better than what is currently standard. If he is not continuously looking for something better, then I am afraid that he is mentally dead. Of course, he has to define "better." He knows well that what he is doing today will be obsolete tomorrow. While seeking for something "better" there should always be present in his thinking the very pertinent admonition by Bacon "What is settled by custom, though it be not good; at least it is fit." That admonition is most significant because it cautions us to avoid novelties simply for novelty's sake. When we as engineers think of change we have in mind not only an alteration in the physical or material way of doing things but also the equally important alteration concerned with the economic aspects. Change to the engineer must encompass both of these aspects. The power engineer must be continually searching the field of science, experiment and experience to see whether there is not some other way in which power can be effectively generated. But in that search he can never lose sight of the equally important economic picture. His final criterion for judging the merit of change is "will the new proposal do an equally effective job for less money?" When a proposed change gives lower cost we are inclined to call the result "progress." And progress is what we seek.

The field of power generation is not peculiar or unique with reference to this whole picture of development and evolution. It has followed the conventional pattern of change—and will, without doubt, continue to do so. When the term "power" is mentioned, I suppose each man present conjures up a different picture. It can mean stationary or transportation service. It can mean big and it can mean small power plants. It can mean steam, or hydro, or internal combustion, or atomic. It can mean mechanical energy or electrical energy output. "Power" can mean a myriad of things and each of us has his own idea on what is embraced by the word. I hope to have most definitions and applications in mind as I discuss the future potential because it is surprising how many lessons can be learned in one branch of the art and transferred to another branch. It is only human to resist that transfer. It is my hope that I, at least, may be able to provoke some original ideas among the audience this evening.

Progress in Power

Power, relatively, is an old and well-established art but that entrenchment is not so firm as to preclude change in the future. This year we are celebrating the diamond jubilee of Edison's original contribution of the electric light to the art of electric power production and use. If we compare the performance of the Pearl Street Plant with the plants of today we find a heat rate of 150,000 Btu per kwhr then and an average of 13,000 Btu per kwhr today. This means that the coal consumption then was twelve times what it is now—to produce a kwhr. This, I submit, is remarkable progress and the entire change has been made since the year 1882. It should also be borne in mind that Edison's plant was initiated a century after James Watt did his original work. There is a further uniqueness about this electric power business this year because for the first time in history we have reached that enviable goal of producing our electric energy for 1 lb of coal per kwhr. This was in April and is the average, not the best, for all public utility plants in the country as they were actually run and loaded. There was no conscious effort to establish a record. It was all in the day's work and constitutes a milestone of which we, connected with the industry, can be justly proud.

It is only reasonable to ask what comes next? If such improvements have already been made in the generation of electric power by steam systems, how can there by any further gain that is worthwhile? Questions of this kind are repeatedly asked and they are by no means limited to the power field. If it were possible clearly and easily to foresee the future, far fewer mistakes would be made along the way.

I am prompted to give you a quotation from Mr. Greenwalt, President of the Dupont Company, in the IBM magazine *THINK* for May 1954.

"It is interesting to note that when anyone in the past has attempted to predict the long-term future, his forecast has turned out to be hopelessly short-sighted and pessimistic. Benjamin Franklin, for example, thought at the end of his life that it would perhaps take centuries to settle the American continent. The State of California stands as a monument to his error. Thomas Jefferson, in announcing the Louisiana Purchase, felt that the territory might be fully occupied after twenty-five generations. The railroad and the steam-boat opened it up to settlement within a few decades. In the early 1900's a gentleman from Philadelphia grew enthusiastic about private motorcars and foresaw the time when there would be a hundred or so in every city. I might add that he viewed this development as a boon to highway safety as it would free the country from drunken riders and wild horses. A British socialist during the nineteenth century foresaw the period when it would be unnecessary for children to work over ten hours a day."

"The economist Jevons, in 1860, was alarmed at the possible exhaustion of the earth's coal supply within a few years. I have heard similar predictions on petroleum almost yearly since my college days. Sir William Crookes, a distinguished scientist, saw early starvation of the race through diminishing supplies of nitrogen. What he did not foresee was that chemistry through nitrogen fixation would within a generation or so prove his error."

Looking Ahead

It is really a very difficult task to try to visualize the future. It is certainly difficult when you try to avoid sheer unabashed speculation of the type featured in popular science and superman journals, and to reach conclusions on a cold, calculated basis. Perhaps it is most helpful to limit the thinking to a short term in the future—not a hundred years from now, but rather within the active working lifetime of mature people, such as those in this room this evening. That means in the next 10, 20, or 30 years. If we can see that far ahead we will have done a great service and projected ourselves into the future about as far as we need go.

We can be certain of one thing in this power field as in all other areas. That one thing is change. On the basis of experience the past teaches us that change is sure. What we do now, we will not do in the future. History is full of examples where people thought that there could be no change. Venice flourished with a high culture—by monopoly. The people of Europe seem to have learned during the crusades that spices offered a very practical way in which to preserve food, or at least to make it more palatable when in dubious condition. Today we largely substitute refrigeration. The Venetians controlled the trade routes between the East and the West, the avenue of commerce for spices. When Vasco de Gama and the other explorers from Portugal, Holland, Spain and England showed a different trade route the monopoly was terminated.

* Presented under auspices of the Philadelphia Sections, ASME and ASCE, at the 21st National Exposition of Power and Mechanical Engineering Philadelphia, Penna., December 6, 1954.

New methods, particularly of navigation, had to be devised to make this alternative route a reality. The result of the change was devastating to the Venetians but a blessing to many other peoples.

It is not my intention to go on with examples of what happened to people and to their civilization when they failed or refused to recognize the inexorability of change. Those of us in the power industry are only human and we will doubtless be subject to the same weaknesses as our forebears. I have every confidence, for example that the steam turbine—the one big device which has made possible the plentiful supply of cheap electric power—must ultimately be displaced by some other way of doing the job. I reach that conclusion when reasoning by analogy. At the time of Watt the one and only important form of energy used for the propulsion of seagoing vessels was the wind. Today wind power is little more than a technical curiosity. Some of us, of course, like to spend some of our free time handling a sailboat during vacation and think we are sailors. The steam locomotive of the Stephenson Brothers flourished unchallenged for over a century or until World War II. The Diesel locomotive, in ten years time, has made the old iron horse little more than a museum piece. The steam turbine started to eclipse the steam engine at the turn of the century. Reasoning by analogy, it is only a question of time, to my way of thinking, before the steam turbine must travel the accustomed route of evolution.

Improvement by Steps

Over the years we, in the power industry, have met the challenge of economics, as posed by a rising price trend in equipment, fuel and labor, by resort to increased size, higher pressures, higher temperatures, greater use of reheat, higher boiler efficiencies, more regenerative feed heating and the like. These improvements have all been of the kind which represent refinements of existing practices. There has been little which can be classified as revolutionary or epoch-making. The efforts have been concentrated on the minutiae. By the accumulation of many small betterment factors we have been able to keep ahead of the deluge of rising prices all about us. We are able to deliver a kilowatt-hour today for less money than we could twenty-five years ago, and without the benefit of government subsidy.

Since World War I there have been three contributions which stand out in my mind in this attempt to meet the exigencies of the situation in the generation of electric power. First was the principle of regenerative feed heating by extraction of steam from the turbine. This not only effected a great saving in fuel but opened the way for the construction of much larger turbines by freeing the exhaust end of much of its capacity limitation.

The second contribution which allowed the development of large furnaces, with heat release rates ranging to 2 billion Btu-per hour in present practice, was the means whereby coal, like oil or gas, could be burned in suspension and/or in a continuous stream. This step led to the pulverized coal firing and cyclone furnace designs with the practical removal of the upper limit of size when utilizing our most plentiful fuel—coal.

The third big step forward is represented by the plant recently announced for the Philadelphia area which, like the previously projected plant in Ohio, breaks through the barrier of the critical pressure region and completely revolutionizes our thinking and our practice, not only on boilers and turbines, but also on all associated components such as feed pumps, feed pump drives, feed pump speeds, condenser contruction, condenser leakage, feedwater purity, steam purity, feedwater heaters, instrumentation and controls, all under emergency conditions as well as normal conditions of operation.

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This temperature barrier is very great and nothing can be said which can overemphasize its significance. The temperature barrier not only blocks development in the steam power field, but even more so are we frustrated in the attempts to perfect gas turbines which will offer useful life periods, genuinely comparable to those obtainable on steam plants. Similarly, the atomic field is largely frustrated on how to use the inherent high temperatures of nuclear reactions—10^6 degree in fission, 10^7 degree in fusion. This problem of supertemperatures is much more severe than the problem of superpressures. Its solution probably calls for a whole new approach to our understanding and knowledge of metallurgy. We must find a solution which is equivalent to the epochal discovery of stainless steel which took us out of the 800 F steam class and opened the vista of 1000 F and the prospect of 1200 F. Beyond this point of 1200 F we must look elsewhere than to 18 and 8 austenitic steel.

It may be that one of the valuable lessons which we will learn from some of the efforts which have been and are being made in the nuclear field and in the jet propulsion field will be the development of new high temperature metals and alloys. We will learn not only the metallurgy, but perhaps even more importantly, the very real problems concerned with their fabrication. If we can

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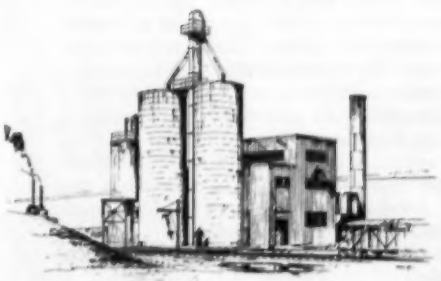

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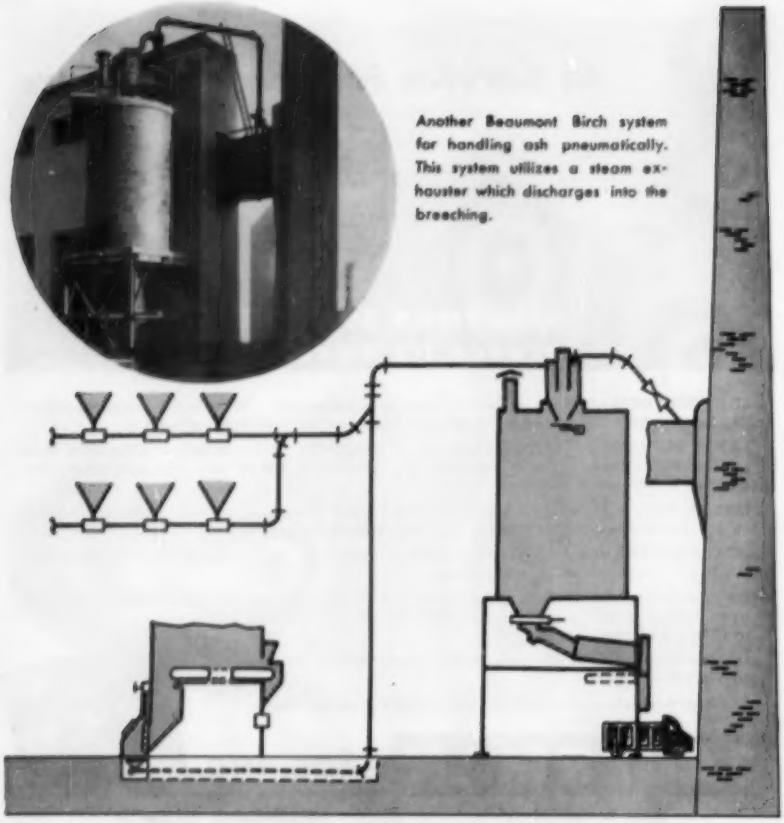

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at least learn such useful lessons then we may rightly feel that some of the many billions of dollars spent for weapons and destructive purposes were employed to good advantage.

Gas Turbine Potentialities

An intermediate step in the program may be to resort to pressure combustion at 5 or 10 atmospheres pressure and accommodate such firing procedures to steam practice. This is essentially an adaptation of the pattern so prevalent in the chemical industry. Practice in chemistry often starts in the test tube and then with progressively larger pilot plants we ultimately reach full scale operations—operations carried out at high pressures. The gas turbine may contain the necessary germ of an idea to carry out combustion at elevated pressures with the maximum heat release rates and with minimum excess air. The furnace gases would be cooled by passage over boiler surface with heat transfer rates far in excess of what we now accept—all because of the greater gas densities and higher mass flows. The gases could leave the boiler setting at temperatures considerably higher than in current practice. They could be reduced in pressure in the gas turbine expander element to provide the driving energy for the compressor. The improvement in overall thermal performance of the combined gas turbine-steam electric plant could conceivably approach a heat rate of the order of 8000 Btu per kwhr. Of course, this entire prospect would be greatly improved if ways could be found to use coal as the source of heat rather than to be limited to natural gas and some fuel oils as is presently customary with the open cycle gas turbine plant.

The closed cycle gas turbine has for some time been favored by many people as a rational solution to this solid fuel problem. Most of the development, however, in gas turbines has been with the open cycle where the burden of heat exchange equipment is eliminated, but the fuel must be carefully selected, either as natural gas or vanadium-free and sodium-free fuel oil. The closed cycle plant does not place the dust loading of coal fires on the sensitive turbine parts but may shift them to heat exchange surfaces. This, at least, would transfer erosion and plugging problems to static rather than dynamic parts.

It is also possible to choose the type and kind of working fluid and its pressure from among a wide variety of alternatives. In fact this could be one way in which to use the gas turbine cycle with nuclear reactors serving as the source of heat. A gas, which does not pick up gamma ray contamination, could conceivably be used not only to cool the reactor but also to act as the thermodynamic fluid and expand directly through the turbine. This would eliminate ex-

pensive heat transfer surface in the more generally preferred liquid cooled reactor-steam generation systems. Its use would entail (1) the maintenance of a fluid which would remain non-radioactive and (2) the perfection of reactor designs, suitable for operation at high temperatures. The fundamentals of gas turbine cycle performance clearly demonstrate that a low temperature gas turbine plant is inherently unsound. Temperatures well above 1000 F, and preferably in the range of 1500 F, are needed to realize the true thermodynamic merits of the gas turbine plant.

Nuclear Power

Temperatures of this magnitude—1500 F, plus or minus—are far from realization on conventional fuel burning plants. They are even more hypothetical today when dealing with nuclear reactors. Most serious nuclear plant proposals, so far, have been confined to lower temperatures even precluding superheated steam and confining operations to the saturated region. Some engineers are inclined to believe that this temperature limitation is of minor significance with nuclear power plants, especially with breeding reactors. With breeding, of course, it can be demonstrated that the cost for fuel or heat, expressed as mills per kwhr, approaches the vanishing point. If the fuel cost is zero, or nearly so, then efficiency in the cycle can be of little significance from the viewpoint of production expense per kwhr. But the picture is more like the economics of hydroelectric practice, where fuel cost is truly zero, and high efficiency (90%) in water wheels is economically demanded in all installations. High efficiency with hydro plants reduces the unit investment of dollars per kw by spreading the heavy capital expenditure for structures through more kilowatts of capacity. In a similar fashion with the nuclear field the heavy investment in reactors, heat exchangers, processing plant could be spread through more kilowatts of saleable electric capacity with the use of low heat rate generating plant, thereby reducing the investment per kw and the corresponding carrying cost expressed as mills per kwhr of salable output.

There is an inclination on the part of many engineers to take a pessimistic view of atomic energy. I do not necessarily subscribe to that pessimism. Those who are hesitant are largely motivated by the inherent difficulties involved in reaching a reliable economic design of power plant. There is no doubt about the many problems which remain unsolved in the nuclear field. Even with the use of a nuclear plant in the competitive area of high cost fuels like gasoline, or in services where the competitive fuel bulk curtails pay-load, as with airplanes, locomotives and ships,

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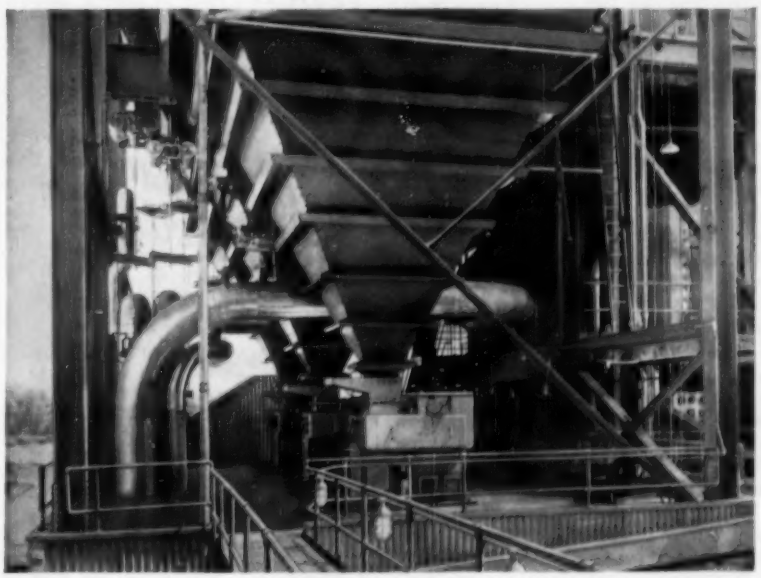

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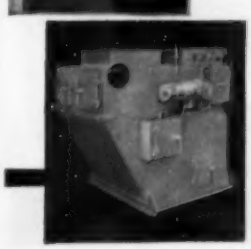

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there are still present problems for which no rational solution is offered at this time. The hazard problem fits into this category. The requirements on exclusion areas for stationary reactors have been greatly liberalized in recent years. The possibility of using underground construction or an explosion-proof shield or shell, together with a better understanding of what can go wrong in a reactor when it gets out of hand, does much to enhance the development and use of stationary nuclear power plants. However, with a transportation plant the hazard problem is not so readily soluble. The risk factor could easily put the power plant outside the range of reality and put the goal farther off in point of time. For example, an accident of a railroad right-of-way, or at an aircraft landing field, or at a wharf in a harbor, could lead to serious uncontrollable contamination of the atmosphere and the surroundings. This factor, in itself, is an impediment to the practical utilization of nuclear power for transportation services where other technical and economic conditions may seem to be so favorable for its advancement. But that factor will not, I am confident, remain as a permanent barrier to the perfection of nuclear power for such services.

Some of those people who are in the pessimistic school on the practicality of nuclear power plants take the view that the harnessing of the sun's rays is a much more fertile field in which to be engaged. Their thinking often includes the belief that were we, as a nation, to spend as much money (more than $10 billion so far) on sun energy applications as we have spent on nuclear research for weapons we would be much closer to realization on the practical harnessing of the sun's rays, than we are today. This may be true but the fact of the matter is that the adaptation of sun's energy is today far removed from reality. The work which must still be done, before we can overcome the many obstacles which lie in the path, to say the least, is staggering. But the enormity of the problem cannot in itself preclude effort, as witness the result with atomic energy development. We must recognize that man will ultimately harness the sun. The sun is our one truly significant source of energy. When he is gone or burned out we need have no more interest in things because we then face the heat death of absolute zero of temperature and infinite entropy.

But to get back to things which are closer to reality we should recognize that the gas turbine is on its way. Many people have been working for a great many years to perfect this device. There are strong incentives to that activity. The inherent high speed means reduction of weight bulk and floor space. The problems of reciprocating masses and forces, are eliminated. Lubrication is simplified and lowered in cost. Water requirements are reduced almost to the vanishing point. Maintenance intrinsically should be lower. These are some of the inducements which have led to the strenuous efforts to perfect the gas turbine plant. It is true that there are plenty of problems unanswered and plenty of disadvantages, but with study, research and development those disadvantages should be reduced. We can face the problem of higher temperatures with far greater assurance than we could only a few years ago. Materials which can withstand the working conditions are becoming more available and their prices should grow more reasonable. Natural gas is an excellent fuel, distillate can be burned without serious trouble, and residual fuel oils seem now to be treatable so that they will be more generally used than formerly. The burning of coal, however, appears to remain a most difficult and unsolved problem. The liquid fuels, however, recommend themselves to transportation services. Gas turbines using them are becoming standard for many airplanes. With some regeneration, intercooling, and reheating they should before long make a serious impression in the locomotive and ship propulsion applications. It would certainly seem as though the day of gas turbine in the range of 1000 hp to 20,000 hp is at hand. These boundaries will not long remain fixed. The efforts underway by automobile manufacturers to produce an inexpensive, reliable, and efficient gas turbine whose capacity is of the order of 100, 200 or even 300 hp are real. The high starting torque of the gas turbine, together with its other characteristics, should assist in the simplification of the entire driving system involving gears, clutches, hydraulic couplings, torque converters, overdrive, and underdrive now found in the automobile, truck and bus constructions. The inherent merits seem to be there and it is only reasonable to expect genuine gas turbine progress in the future.

In this entire consideration of the power problem we should not lose sight of the broader problem of energy supply. Dr. Weaver, of the Rockefeller Institute and President of the American Association for the Advancement of Science, in a paper of "People, Energy and Food", *The Scientific Monthly*, June 1954 had this very striking comment to make:

"In the United States, each individual person uses, each day, about 3,000 calories as food. Each United States inhabitant averages more than 40 times as much, or about 125,000 calories per day for heat and power. It is, at first hearing at least, surprising that in our own country about 25 per cent of our total energy bill is devoted to space heating—to keep our buildings warm—whereas only one-tenth of that amount, or about 2.5% of the total energy bill, is for food.

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"For the planet as a whole, the figures, necessarily rough, appear to be that every individual person on earth uses up, on the average, about 2,400 calories per day for food and about 6,000 calories per day for heat and power. Anyone who is intrigued with oversimplifications might very well look at these figures—3,000 and 125,000 for the United States, and 2,400 and 6,000 for the earth as a whole—and ask himself if he knows of any more compact explanation than is found in these contrasting numbers of the fact that the United States is variously respected, feared, admired, envied, and disliked by the other peoples of this earth."

These are some of the things which lie ahead for us in the power field. We must continue to recognize that change is certain. We simply will not continue to manufacture kwhrs the way we do now or at the price we now pay. If we feel that our 250 or 300 MW units, at supercritical pressures, are the ultimate, I know that we are placing ourselves in the same position as those planters in the South who believed that indigo would always be grown and rice always cultivated in ways which were nearly perfect at the time and which seemed to be immutable. We must learn, if we can, from such experiences. I say "if we can" because the human race seems to be limited to learn only by experience and experience is a hard taskmaster. Change is certain. But you and I must see to it that change means progress, both technical and economic progress. Not just novelty, but progress, so that we can produce cheaper kwhrs.

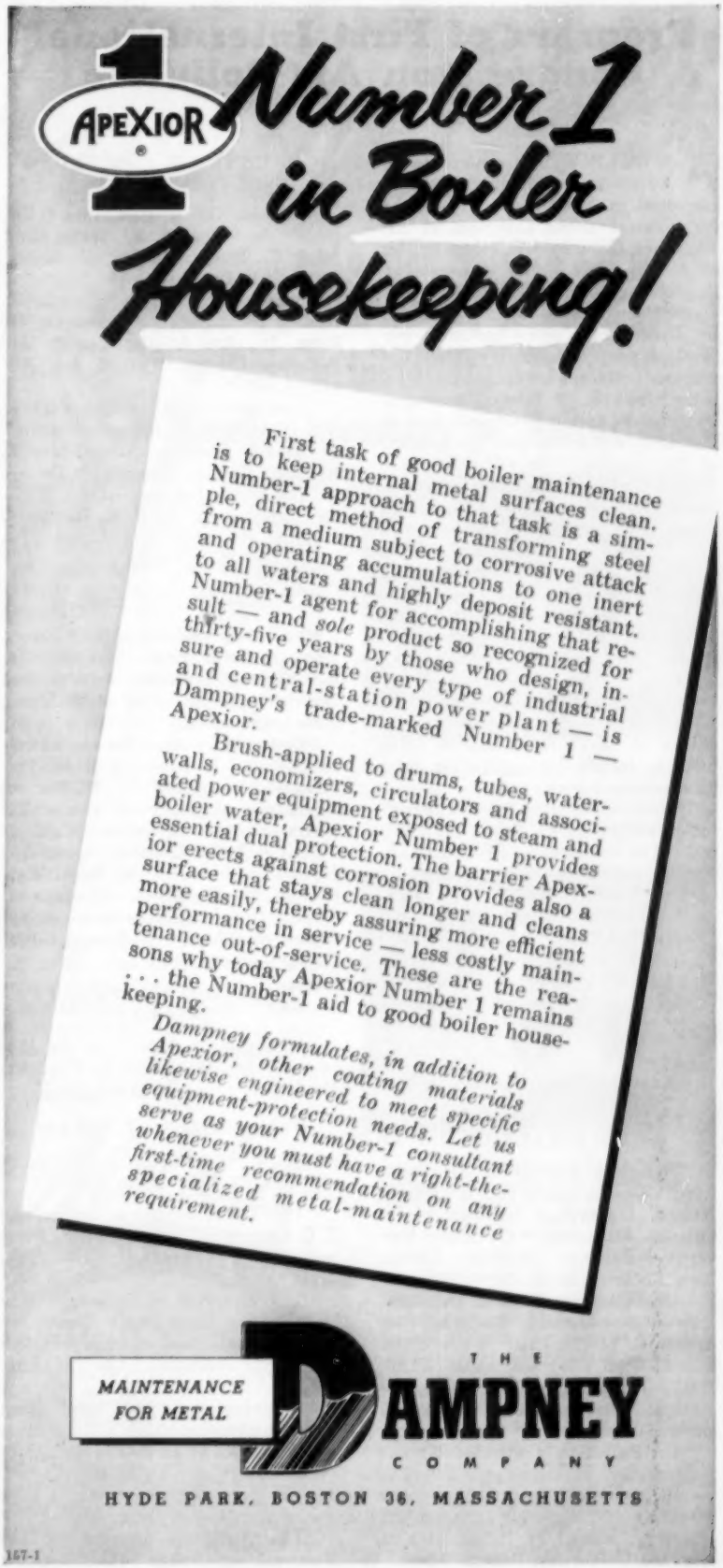
I should like to leave you with one further quotation—from Winston Churchill, and so devastatingly worded, "There is nothing wrong with change—if it is in the right direction."

Obituaries

Mr. William Frye, 77, a director of Chain Belt Co. and its former president, died November 16, 1954. Mr. Frye had been associated with Chain Belt Co. for 60 years.

Dr. Max Jakob, 75, one of the world's foremost authorities on heat transfer and thermodynamics, died of a heart attack at his home recently. Since 1937 he had served as research professor of mechanical engineering at Illinois Institute of Technology and consultant in heat research.

Prof. Lionel S. Marks, a leading authority on engine design and a pioneer in combustion engine development, died January 6 at the age of 83, of a heart attack. Prof. Marks had retired in 1940 after serving forty-six years at Harvard University.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Program of First International Congress on Air Pollution

A WORLD-WIDE conference of scientists and engineers will be convened in New York City at the First International Congress on Air Pollution, to be held in Hotel Statler on March 1 and 2 under the sponsorship of the American Society of Mechanical Engineers. The meeting will be divided into seven technical sessions, dealing with different phases of current pollution investigation.

Sir Hugh E. C. Beaver, managing director of Arthur Guinness, Son & Co., Ltd., will be the principal speaker at the meeting. He will deliver the Calvin W. Rice lecture of The American Society of Mechanical Engineers, which is sponsoring the congress as a part of its 75th anniversary observance. Sir Hugh is chairman of Great Britain's Government Committee to Examine the Nature, Causes and Effects of Air Pollution. His lecture before the Congress entitled "Air Pollution: The Growth of Public Opinion," will be based upon a final report, now in preparation, on the causes of 1952's fatal London smog and on means for controlling such smogs in the future.

Two documentary films on air pollution will be shown during the meeting. The Engineering Research Laboratory of New York University will present "Wind Tunnel Scale-Model Investigation of Power Plants." The second film, entitled, "Guilty Chimneys," is being sponsored by The Gas Council of London, England.

Details of the program are as follows:

Tuesday, March 1, 9:30 a.m.

GAPS IN OUR KNOWLEDGE OF AIR POLLUTION

"Biological Aspects of Air Pollution: Needed Research" by **Norton Nelson,** Director of Institute of Industrial Medicine, New York University—Bellevue Medical Center, New York, N. Y.

"Air Pollution Control: Administrative Needs and Patterns" by **Arthur C. Stern,** Chief of Air Pollution Control Program, U. S. Public Health Service, Department of Health, Education and Welfare, Cincinnati, Ohio.

"Air Pollution Control: Needed Engineering Research and Development" by **Leslie Silverman,** Associate Professor of Industrial Hygiene Engineering, School of Public Health, Harvard University, Boston, Mass.

CURRENT AIR-POLLUTION DEVELOPMENTS

"Exhaust Gases from Diesel Engines" by **Rogers F. Davis** and **John C. Holtz,** Bureau of Mines, Pittsburgh, Penna.

"Incinerator Design Standards: Research Findings" by **Andrew H. Rose, Jr.,** Los Angeles County Air Pollution Control District, Los Angeles, Calif.

"Measurement of Average Particle Size in Aerosols by Light-Scattering" by **David Sinclair,** Johns-Manville Research Center, Manville, N. J.

"The Sarnia Survey: Action Without Compulsion" by **B. C. Newbury,** Ontario Research Foundation, Toronto, Ontario, Canada.

Tuesday, March 1, 2:00 p.m.

"Unsolved Meteorological Problems in Air Pollution Control" by **E. Wendell Hewson,** Professor of Meteorology, University of Michigan, Ann Arbor, Mich.

"Biological Systems for the Identification and Distribution of Air Pollutants" by **John T. Middleton,** University of California Citrus Experiment Station, Riverside, Calif.

"Air Pollution Control: Associated Health Implications" by **E. A. Watkinson, M. D.,** Chief, Occupational Health Division, Department of National Health and Welfare, Ottawa, Ontario, Canada.

Banquet, 6:30 p.m., Tuesday, March 1

"Management Aspects of Air Pollution" by **G. Edward Pendray,** Pendray & Co., New York, N. Y.

Wednesday, March 2, 9:30 a.m.

SULFUR DIOXIDE — TREATMENT AND RECOVERY

"The World Supply of Sulfur" by **J. C. Carrington,** vice president, Freeport Sulfur Company, New York, N. Y.

"The Removal of Sulfur Dioxide from Power Plant Stack Gases" by **R. L. Rees,** chief chemist, British Electricity Authority, London, England.

"Recovery of Sulfur Dioxide from Coal Combustion Stack Gases: Pilot Plant Studies of an Ammonia Scrubbing Process" by **L. B. Hein,** chief, defense processes, Tennessee Valley Authority, Wilson Dam, Alabama.

"The Ammonia Process for the Removal of Sulfur Dioxide from Flue Gases" by **H. E. Newall,** Department of Scientific and Industrial Research, Fuel Research Station London, England.

EXPERIENCE IN AIR POLLUTION ABROAD

"Influence of the Size of the Dust Outlet of Cyclones on Their Efficiency" by **H. J. Van Ebbenhorst Tengbergen,** Mining Division, Staatsmijnen in Limburg, Centraal Proefstation, Treebeek, The Netherlands.

"Experience with Air Pollution In Holland" by **A. J. Ter Linden,** Professor Engineer, Technische Hogeschool Laboratorium voor Warmte en Stoftechniek, Delft, The Netherlands

"Abiotic Disease in Forest Stands Caused by Sulphurous Gases" by **Natalina Ferreira Dos Santos Azevedo,** Estacao Agronomica Nacional Sacavem, Portugal.

Wednesday, March 2, 2:00 p.m.

"Refinery Sulfur Recovery Aids Air Pollution Control" by **G. E. Smalley** and **James W. Klohr,** The Ralph M. Parsons Company, Los Angeles, Calif.

"Sulfur in Iron and Steel Making" by **T. P. Colclough,** Technical Adviser, British Iron and Steel Federation, London, England.

"Recovery and Utilization of Sulfur from Coke Oven Gas" by **J. K. Kurtz,** Bethlehem Steel Company, Sparrows Point, Md.

"Air Pollution Caused by Combustion Products and Industrial Activity" by **Melchiorre De Chigi,** Director, Hygiene Institute, Padua University, Italy.

"Collective Toxicity in Italy Caused by Industrial Atmospheric Pollution" by **Giovanni Pancheri,** Director, Medical Division, Ente Nazionale per la Prevenzione degli Infortuni, Rome, Italy.

"Practical Performance with Test Results of Well-Known Types of Dedusters" by **C. J. Stairmand,** Imperial Chemical Industries Limited, Billingham, Co., Durham, England.

Personals

Catalytic Combustion Corp. has announced the appointment of **Ted Grimac** as district manager for field engineering and sales operations covering Eastern Pennsylvania and Southern New Jersey.

Walter Rothenhoefer has been elected a vice president of Eastern Gas and Fuel Associates, president of New England Coal and Coke Co., and president of Castner, Curren & Bullitt, Inc. He succeeds, in the three

positions, **Mr. H. B. Baird**, who retired in December 1954.

General Electric Co. has announced the election of three vice presidents. The new vice presidents are: **Francis K. McCune**, general manager of the atomic products division; **Robert L. Gibson**, general manager of the chemical and metallurgical division; and **Willard H. Sahloff,** general manager of the small appliance division.

Carl F. Norberg was elected president of The Electric Storage Battery Co. at a recent meeting of the board of directors. The action followed the resignation of **S. Wyman Rolph** as president, chairman of the board and a director, who is retiring after 38-years' service.

The resignation of **Edward R. Trapnell**, who has served for the past two and a half years as special assistant to the general manager in charge of congressional relations, has been announced by the U. S. Atomic Energy Commission.

Willis I. McCord, formerly with the Allen B. DuMont Laboratories, has been made manager of electronic sales by Diamond Power Specialty Corp. He has served with the DuMont organization for ten years in various capacities including research, broadcasting, and the sale of television broadcast equipment.

The appointment of **Dr. Kurt C. Frisch** as assistant manager of research has been announced by E. F. Houghton Co. of Philadelphia. Dr. Frisch has been supervisor of organic research in the Houghton Laboratories since 1952. He will be succeeded in that position by **Dr. Ellis Abrams**, who was formerly associated with Quaker Chemical Products Corp.

At a board of directors meeting of Beaver Pipe Tools, Inc., **Mr. Charles T. Everett** was elected president and general manager, as well as a director of the Beaver firm.

Dr. Lawrence R. Hafstad, who retired recently as director of the Atomic Energy Commission's division of reactor development, has been granted the AEC's distinguished service award. Dr. Hafstad has accepted a position with the Chase National Bank of New York after nearly six-years' service with the AEC.

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Personals

The election of **Charles L. Hulswit,** president of Rockland Light and Power Co., as a director of The First National Bank of Spring Valley, New York has been recently announced.

Scoville Manufacturing Co. has announced the appointment of **Charles K. Stickney** as chief engineer of that company. Mr. Stickney succeeds **Leo J. Niekerk** who retired December 31, 1954. **Thomas P. Healey** has been appointed assistant power plant engineer.

According to the announcement of Gibbs & Hill, Inc., New York engineers and constructors, **H. Everett Woodruff** has been elected to that firm's board of directors. Mr. Woodruff is vice president in charge of the investment department, New York Life Insurance Company.

Strong, Carlisle & Hammond Co. has announced the appointment of two new industrial distributors to handle the Strong Steam Specialty line. Direct representatives for New York and northern New Jersey will be Seco Industries, Inc. Mr. **C. W. Mann,** former district manager for this territory, is joining the Seco organization which is headed by **Mr. Charles Sechtig.** Rhodes Equipment Co., will be the direct factory representative for Strong Steam Specialties in the St. Louis area.

Business Notes

The Franklin Institute Laboratories for Research and Development recently announced the establishment of a new research section for heat and power. One major activity of this new section will be research on problems inherent in the design of atomic plants.

With some twelve major national scientific and engineering organizations participating, the first all-embracing convocation in this country devoted to peace time problems of nuclear engineering and the related sciences will be held late in the Fall of 1955. The week-long Nuclear Congress will bring to the public the presentation and discussion of scores of technical papers by eminent men in these fields.

Westinghouse Electric Corp. plans to build new jet engine research and development facilities which will cost more than $12\frac{1}{2}$ million. The new facilities will be located at the present site of the huge jet engine plant south of Kansas City. The firm of Sanderson and Porter of New York will be agents for all new construction involved.

A new 100,000 kw unit costing $14,000,000 that doubles the electric power generating capacity of the **Virginia Electric and Power Co.'s** Portsmouth station has recently gone into full load commercial operation. This brings the Virginia Electric and Power Co. system's total generating capacity to more than 1,000,000 kw.

A private international program to develop the peaceful uses of atomic energy has been organized by a group of the nation's leading scientists, educators and industrialists. The program is to be launched by a newly-created organization called the **Fund for Peaceful Atomic Development, Inc.**

The Daniel Construction Company has recently made several changes in their corporate officers and has also announced the opening of two additional offices. Charles E. Daniel, president, becomes chairman of the board, and is succeeded as president by his brother, R. Hugh Daniel, who will now hold the offices of president and treasurer. L. L. Longcrier will be vice president and manager of the Virginia office, a new division, with offices in Richmond, and Harry J. Stellman will serve as manager of the new Florida branch, with officers in Jacksonville.

Plans for the continuing expansion of the **American Gas and Electric Co.** system by the construction of a 225,000-kw steam-electric generating unit to be built at the Muskingum River Plant of the **Ohio Power Co.,** near Beverly, Ohio, the newest station on the American Gas and Electric system, were recently announced. Estimated construction costs of the unit are $29,600,000.

Development of the program for its first General Assembly, a move to invite certain organizations to membership, designation of a representative to UNESCO and nominations of officers were recently announced by **Engineers Joint Council.** EJC is composed of eight major national societies with a total membership of 170,000. The General Assembly will have as its basic theme the increase of unity in the profession.

The **Atomic Industrial Forum, Inc.,** announced early last month the formation of an industrial nuclear reactor materials committee. Companies cooperating in the organization of the committee are **Allegheny Ludlum Steel Corp., Aluminum Co. of America, The Babcock & Wilcox Co., Climax Molybdenum Co., Interna-**

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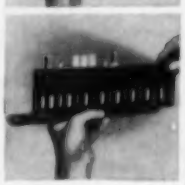

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tional Nickel Co., Lukens Steel Co., Nuclear Metals, Inc., Republic Steel Corp., Titanium Metals Corp. and **Vanadium Corp. of America.**

The **Pennsylvania Crusher Co.**, a subsidiary of **Bath Iron Works Corp.** since 1947 was merged with the parent company on December 31, 1954. As of that date the business became known as the Pennsylvania Crusher Div. of Bath Iron Works Corp.

Detroit Edison Co. announced the establishment of a laboratory at their Delray generating station to test parts for an atomic-fueled electric power plant.

Book Review

Engineering Analysis

By D. W. Ver Planck and B. R. Teare Jr.

Subtitled "An Introduction to Professional Method," this text marks an important departure from many engineering books because of its strong emphasis on methods of thinking. What the authors are attempting to do is to provide a basic philosophy of problem solving. This philosophy then becomes an integral part of the engineer's way of meeting new situations during his professional career. The emphasis throughout the book is on the development of well-ordered analytical thought processes.

Concern with methods of thinking is highly important in engineering education, for there is the danger that the learning of many specific techniques will obscure the overall view of problem solving. The authors express this concept as follows:

"We feel that, whatever the merit of learning more powerful and more general techniques of mathematical manipulation, there is still urgent need to help the student learn how to do the whole process; how to take the often crude engineering situation and simplify it; then translate it into mathematics himself under conditions in which he does not know at the start just what kind of mathematics is needed; and after he gets a mathematical result carry the work toward an engineering conclusion."

Throughout the book an attempt is made to express problems in the informal, undefined sense in which they are generally encountered in engineering practice. This gives more reality to the problem situations, most of which are selected from subjects of interest to students in mechanical, electrical and industrial engineering. Although the text is basically intended for college juniors, seniors and first-year graduate students the practicing engineer will find the methodology proposed worthy of serious study. Topics are included from dynamics of translation and rotation, electric circuits, heat transfer, solution of linear differential equations, integration by graphical and numerical methods and dimensional analysis.

Both of the authors are associated with Carnegie Institute of Technology and have backgrounds of both teaching and industrial experience extending back more than twenty years. At present Dr. Ver Planck is head of the department of mechanical engineering and Dr. Teare is dean of the college of engineering and science.

Back in May 1952 an editorial appeared in this publication entitled "What about the 'How' in 'Know-How?'" Among other things it urged that more attention be given to the underlying methods of engineering thinking so that there could be a better understanding of the "how" in the daily activities of engineers. This outstanding book well exemplifies the philosophical approach suggested in that editorial. It is to be hoped that the text will not only receive wide use in courses in engineering analysis but also find a place in the libraries of many graduate engineers.

There are 344 pages in the book which is priced at $6.

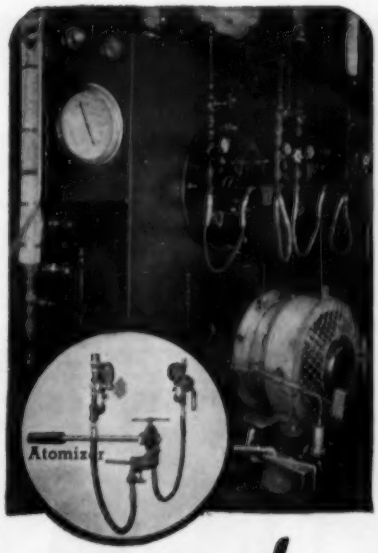

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FIG. 29
Cylinder with Impeller

FIG. 17-28
Cylinder

FIG. 215
Flanged

FIG. E-57
Double Window

FIG. 212
Visibility Welding Neck or Screw

FIG. E-811
Flapper

FIG. E-1810
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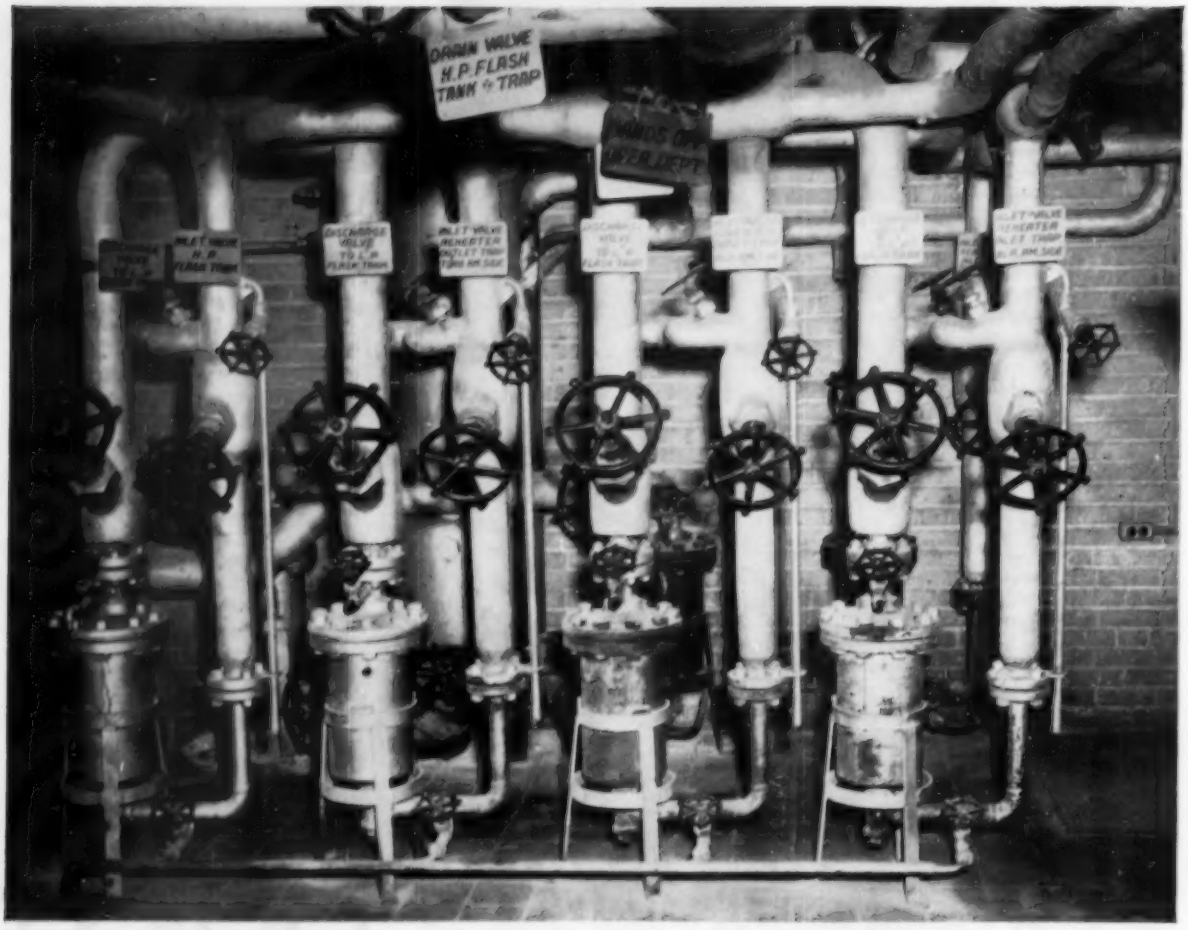

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Typical Armstrong high pressure trap users:

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Ohio Power Company, Phila, Ohio

Kansas City Power & Light—Kansas City, Mo.

Georgia Power Company—Yates, Macon, McManus, Georgia

United Illuminating Company—New Haven, Conn.

Philadelphia Gas & Electric—Philadelphia, Pa.

San Diego Gas & Electric—San Diego, Calif.

Wisconsin Electric Power Company, Milwaukee, Wisconsin

Northern States Power Company—St. Paul, Granite Falls, Black Dog, Minn.

Cincinnati Gas & Electric Company, Cincinnati, Ohio

One of the readers of a power plant publication recently asked, "which is the best device for removing condensate from lines carrying superheated steam . . ."

Eleven readers answerd this published question. *All* agreed, from experience, that steam traps are best.

Traps are automatic. Traps prevent steam loss. Traps take care of boiler carryover. Traps are available with sufficient capacity to take care of any condensate load. Traps don't "forget" to drain the lines.

Since 1929, Armstrong inverted bucket forged steel steam traps have kept pace with the trend to higher steam pressures. Today, they are widely recognized as essential safety devices in leading power plants throughout the world operating at pressures up to 2400 psig.

For safe, dependable drainage of superheated steam lines, get the facts about Armstrong traps. Call your local Armstrong Representative or write Armstrong Machine Works, 814 Maple St., Three Rivers, Michigan.

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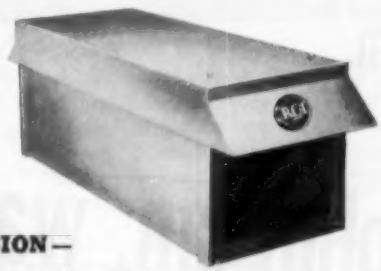

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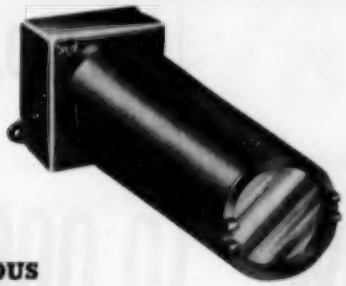

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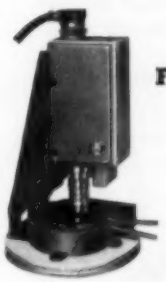

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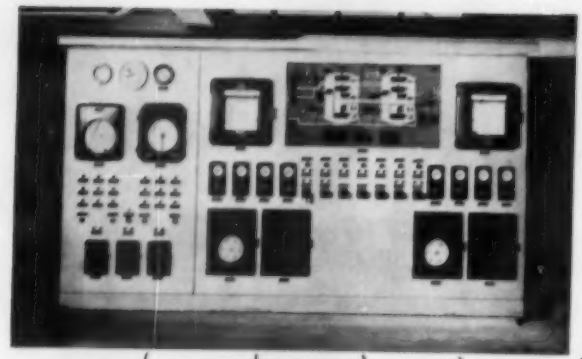

10,000,000 ohm-cm.

10,000,000 ohm-cm.

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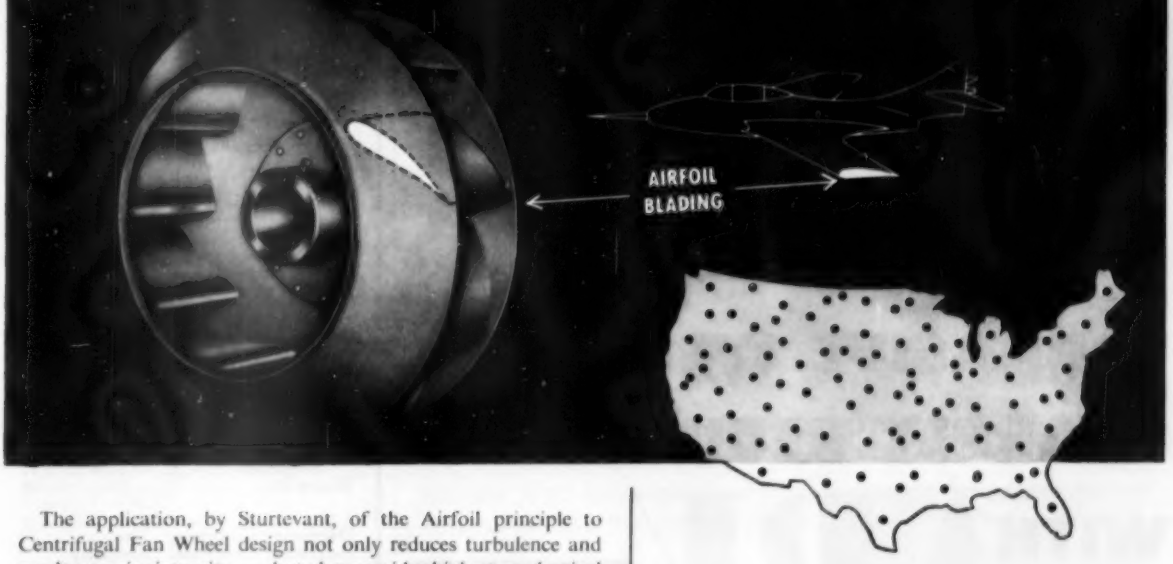
WESTINGHOUSE FANS WITH AIRFOIL BLADING REDUCE NOISE INTENSITY 65%



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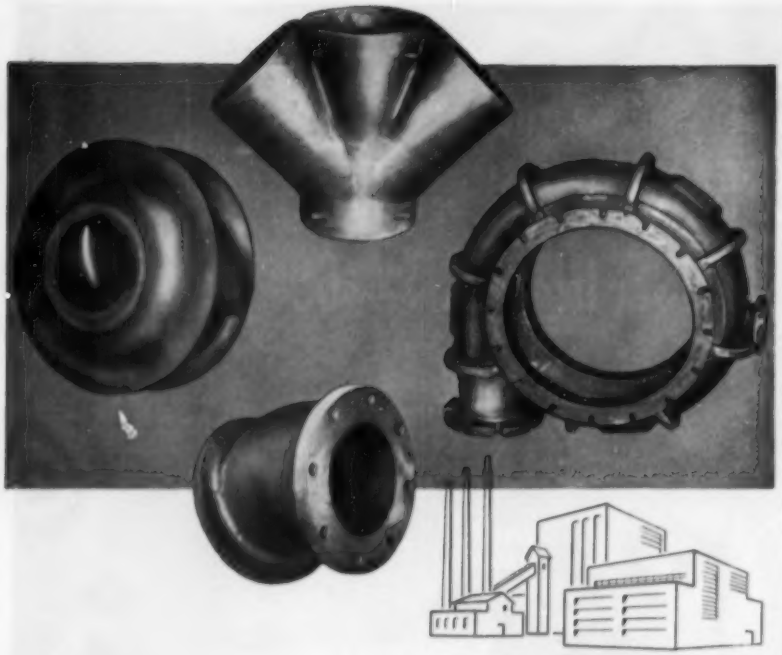

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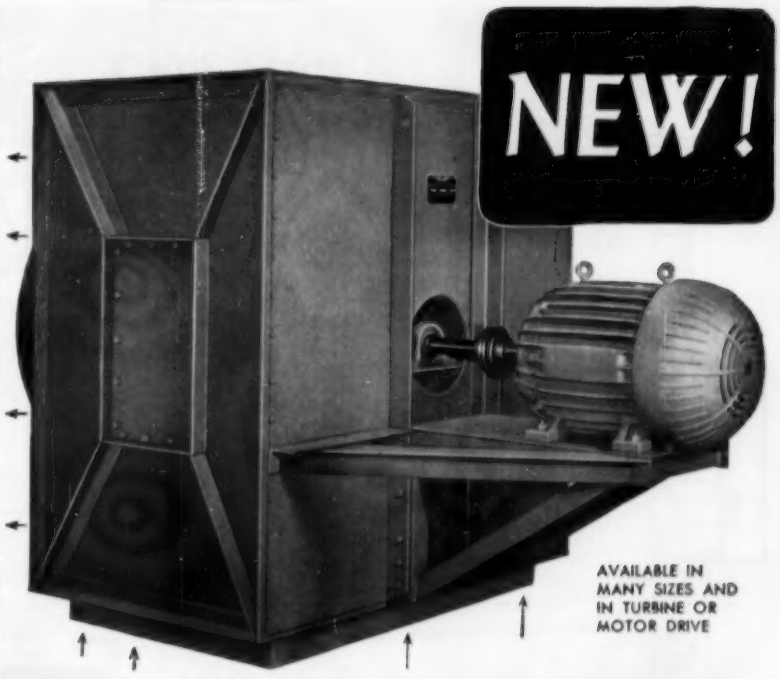

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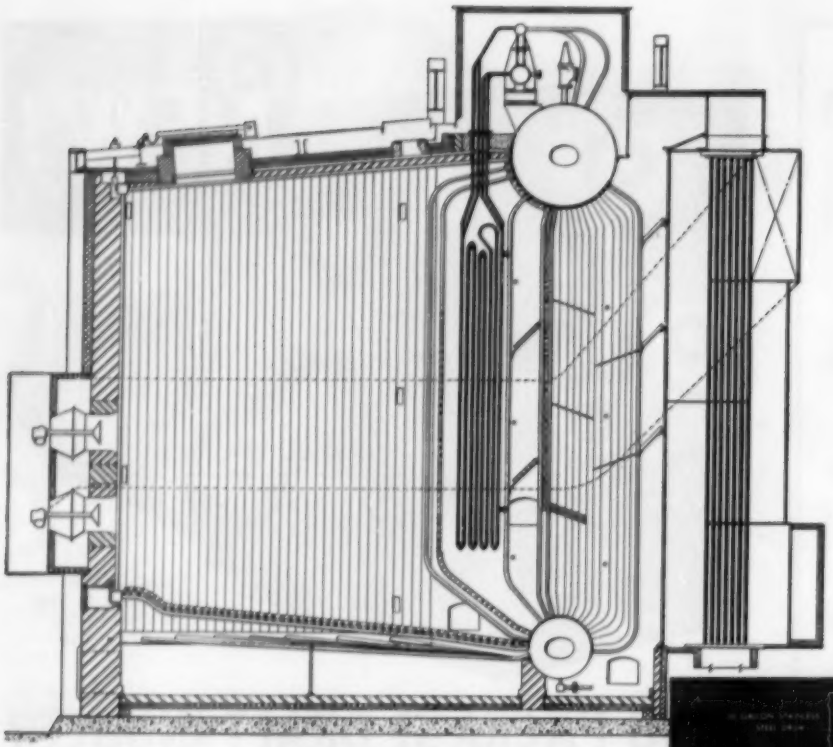

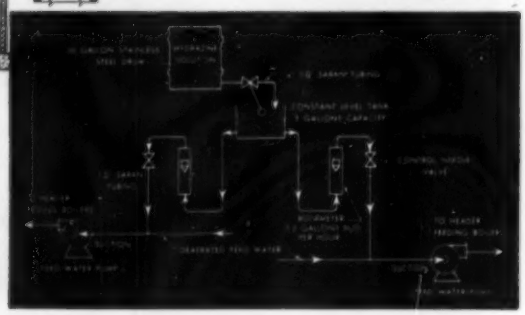

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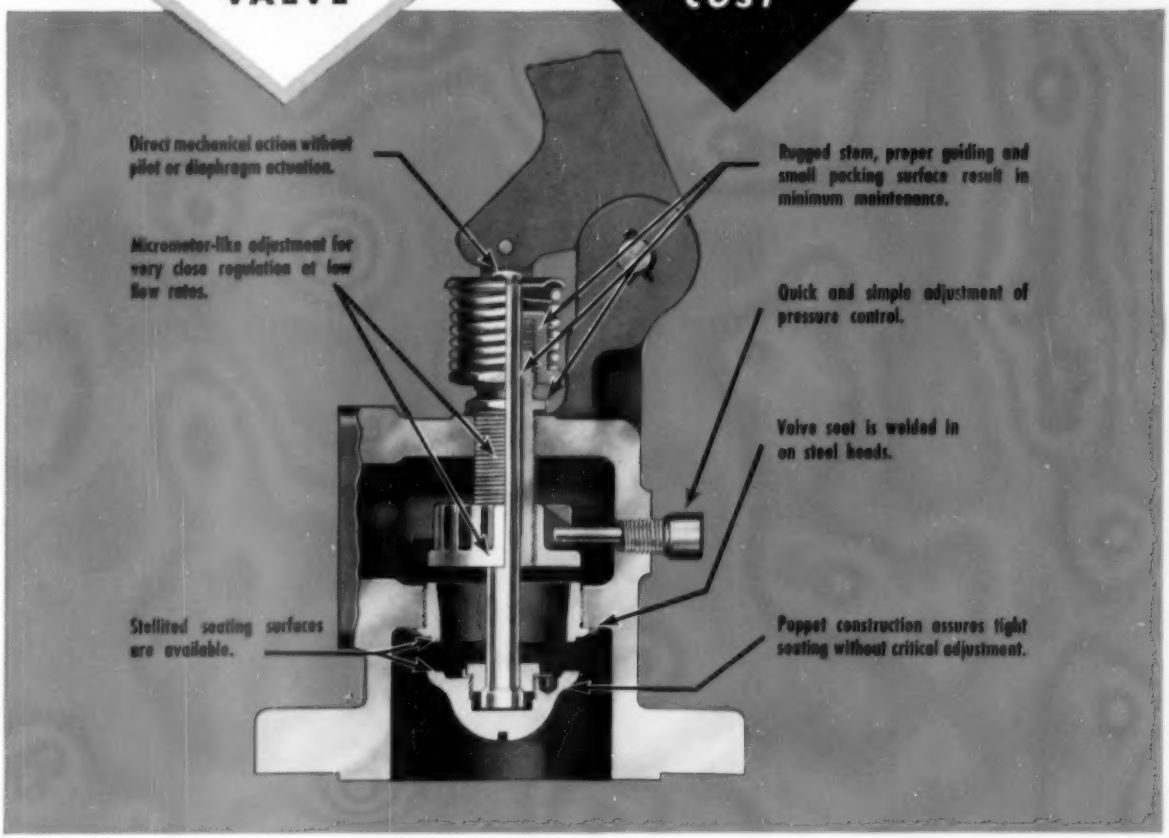
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